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UNGULATE USE OF SOME RECENTLY RECLAIMED STRIP MINES IN SOUTHEASTERN BRITISH COLUMBIA

by

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ABSTRACT

Wild ungulate use and vegetation of three reclaimed strip mines in southeastern British Columbia were assessed over a three year period (1974-1976). Ungulates were attracted by water and "islands" of native vegetation on the seeded areas. Heaviest use occurred close to cover, both along the edges of the disturbed areas and near the vegetation "islands". Ungulate use of the seeded areas increased over the study period but was always less than use on the surrounding undisturbed areas. Forage yields from the seeded areas did not vary significantly at the Placid Oil mine or at McGillivray Pit but, at Erickson Pit, there were significant changes primarily due to variations in production of sweet clover and alfalfa. Plant species diversity on the seeded areas of the three mines showed few changes during the study period. Only a few native plant species successfully invaded the seeded areas.

INTRODUCTION

Since 1969, reclamation of abandoned strip mines has become necessary by law in British Columbia. As a basic statement of policy on reclamation, Section 8 of the Coal Mines Regulation Act and Section 11 of the Mines Regulation Act begin:

> "It is the duty of every owner, agent, or manager of a mine to institute and carry out a programme for the protection and reclamation of the surface of the land and watercourses affected thereby, and, on the discontinuance or abandonment of a mine, to undertake and complete the programme to leave the land and watercourses in a condition satisfactory to the Minister; ....."

At first, these acts applied only to surface mines, gravel pits and industrial mineral quarries, but further amendments in 1971 and 1973 also made it mandatory to reclaim exploration roads, and surface disturbances associated with both underground mines and milling facilities.

With reclamation, these disturbed areas are more likely to return to productive vegetation and eventually to natural plant communities. Since returning disturbed areas to their original state is usually impossible, the best approach is to restore these areas to their most practical and productive use within the shortest time. In other words, disturbed land should be managed for the best possible use compatible with its biophysical capabilities, following a prepared land use plan.

In southeastern British Columbia, many strip mines occur on ungulate winter ranges (Demarchi 1968). Whether or not present reclamation techniques benefitted wild ungulates was virtually unknown. Several studies on wildlife-reclamation interactions have been described for the eastern United States (Holland 1973, Mumford and Bramble 1973, Riley 1963, 1954 a and b, Yeager 1940). However, most of these papers were primarily concerned with small mammals and birds; ungulate use was recorded incidentally.

As no information was available for British Columbia, the British Columbia Fish and Wildlife Branch began a two-part study on ungulates and strip mines. The first part was a reconnaissance survey on the effects of coal exploration activities on the habitat and movements of ungulates (Stanlake, Stanlake and Eastman 1976). The second part, reported here, was a study of ungulate use of recently reclaimed open pit mines. Field work occupied three summers from 1974 to 1976, and a short period in the summer of 1977. The first two years' field work were reported by Taylor and Hayward (1975) and Stanlake and Stanlake (1976), respectively. The present report summarizes the results of all previous work and offers some suggestions on improving future mine reclamation to benefit wildlife.

This study on the ungulate use of reclaimed strip mines had the following objectives:

1. To document winter use by ungulates of reclaimed mine sites and adjacent undisturbed land.

2. To describe the vegetation of disturbed and adjacent undisturbed land.

3. To develop recommendations that would improve enhancement and protection of wildlife values on reclaimed mine sites.

It is important to note that the mines examined in this study ranged from 10 to 40 ha. They are much smaller than the large scale strip mining operations such as those by the Fording Coal Company at Eagle Mountain, and by Kaiser Resources at Harmer Ridge. Thus our results mainly apply to the smaller strip mines since the large scale operations have additional environmental ramifications simply because of their size. Application of our results to large scale, high elevation mines must be carefully done.

ACKNOWLEDGEMENTS

We would particularly like to thank Bev Taylor and Claudia Hayward, who established the transects in 1974 and collected the first year's data. Thanks go also to the Johnston family at Placid Oil Mine, all the personnel of the Environmental Services Division of Kaiser Resources Ltd. and John Dick, Fish and Wildlife Branch, for their technical advice and help on strip mining and reclamation procedures. We appreciate the constructive criticism provided by John Dick, Bruce Pendergast and Ken Sumanik on earlier drafts of this report.

STUDY AREAS

The general area of interest was southeastern British Columbia, commonly known as the East Kootenay. The diverse and mountainous landscape is part of the metamorphic Front and Kootenay Ranges of the Rocky Mountains and the sedimentary strata of the Fernie Coal Basin (Holland 1964). The topographic diversity is reflected in the vegetation - five biogeoclimatic zones occur: 1. wet subzone ponderosa pine-bunchgrass; 2. dry subzone Interior western hemlock; 3. Interior Douglas fir; 4. Engelmann spruce - subalpine fir; 5. alpine tundra (Krajina 1965). The climate is classified as Humid Continental according to Koppen's system (Strahler 1960). Winters are cool and snowy, and summers are hot and dry. Large mammals are numerous with six species of ungulates recorded. Much of the lower elevations are "important winter concentration ranges for ungulates (deer*, moose, sheep, elk and goats) that summer over a widespread area" (Canada Land Inventory 1970).

We concentrated our study on three strip mines: Placid Oil, situated 48 km east of Cranbrook; and McGillivray and Erickson Pits, both found near Sparwood (Fig. 1). Common features of these three sites are their small size (less than 50 ha each) and their westerly exposure (Table 1). All occur on prime big game ranges.

Table 1. Major features of the three reclaimed strip mines studied.

Name of mine	Major wintering ungulates	Type of mine	Area disturbed (ha)	Elevation (m)	Aspect
Placid Oil	bighorn sheep, mule deer, elk	copper	40	900-1050	SW
McGillivray Pit**	elk, mule deer	coal	10	1475-1500	S to SW
Erickson Pit**	elk, mule deer	coal	12	1300-1400	SW

** Kaiser Resources property

* Common and scientific names are in Appendix I.

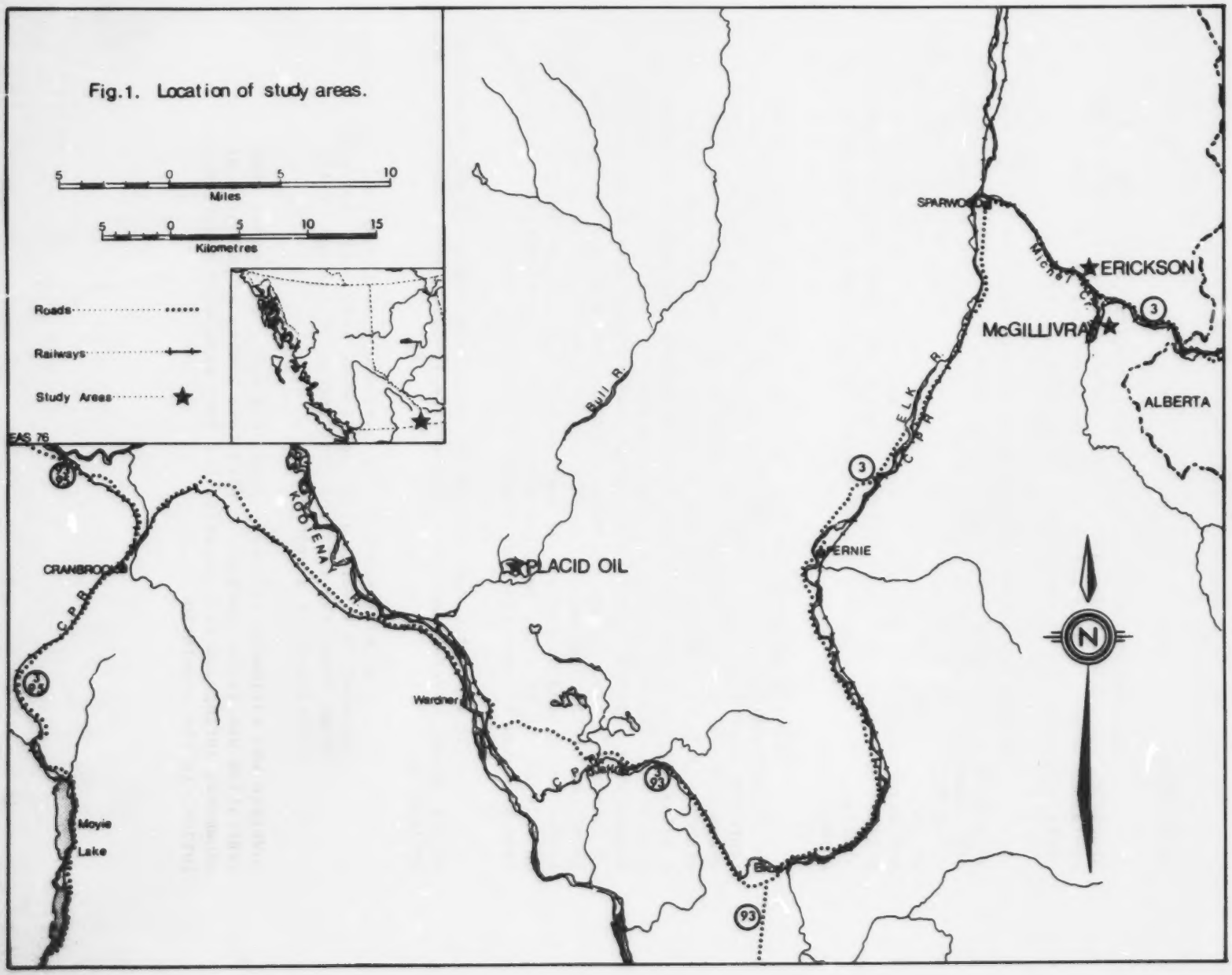


Fig.1. Location of study areas.
5 0 5 10
Miles
5 0 5 10 15
Kilometres
Roads
Railways
Study Areas
SPARWOOD
ERICKSON
McGILLIVRAY
ALBERTA
Michel Cr.
ELK R.
Bull R.
3
FERNIE
PLACID OIL
CRANBROOK
C.P.R.
KOOTENAY R.
Wardner
Moyie
Lake
93
N

METHODS

VEGETATION

Vegetation-types and their plant species composition and abundance were described. Also, annual yields were estimated for the reclaimed areas. Typing and descriptions were done in 1974 with additional plant cover estimates done in 1975 and 1976.

Before going into the field, available maps and air photos were used to determine tentative vegetation-types, potential study sites and transect locations. A field reconnaissance was done to check presumed differences in vegetation such as forest canopy, maturity and species of trees, density of understory vegetation, height and density of shrubs, and major understory species. A vegetation-type or plant community was defined as a vegetation association in which all these factors were similar. The resloped and seeded areas were considered as separate communities.

Representative sites for each community were chosen during the field reconnaissance. We selected two vegetation transects to represent each type, except the shrub community at the Placid Oil Mine, where six transects were chosen. Transects were marked at each end with 0.6 m metal stakes, anchored in the ground or in a rock cairn. A metal tag bearing the code for the vegetation-type and the transect number was attached to the stake that marked the start of the transect. Stakes were painted fluorescent orange, and flagged with three pieces of surveyor's tape - blue and white, orange, and blue and white. The locations of the beginning of each transect were described using prominent landmarks, ground distances and compass bearings. These descriptions are on file at the Wildlife Research Section office in Victoria. Flagging tape was used to mark the way to some of these locations.

The floristic composition of each plant community was determined by the canopy coverage method of Daubenmire (1959), where canopy cover was defined as:

> ". . . an expression of the percentage of the ground included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individuals of a species . . . "

Coverage was estimated primarily from July until mid-August when vegetation was fully developed. With this timing we may have missed ephemeral spring and fall species, but they made only minor contributions to the vegetation.

In the field, canopy-coverage was estimated and recorded for each species occuring in 20- x 50-cm quadrats or Daubenmire frames, using a 1 to 6 scale of canopy-coverage (Table 2). Coverage was determined separately for each species in a quadrat, regardless of where the individuals were rooted and intra-specific overlap (Figure 2). Since the canopies of different species are commonly superimposed over the same ground area, the sums of coverages for a stand commonly exceed 100 percent (Demarchi 1971).

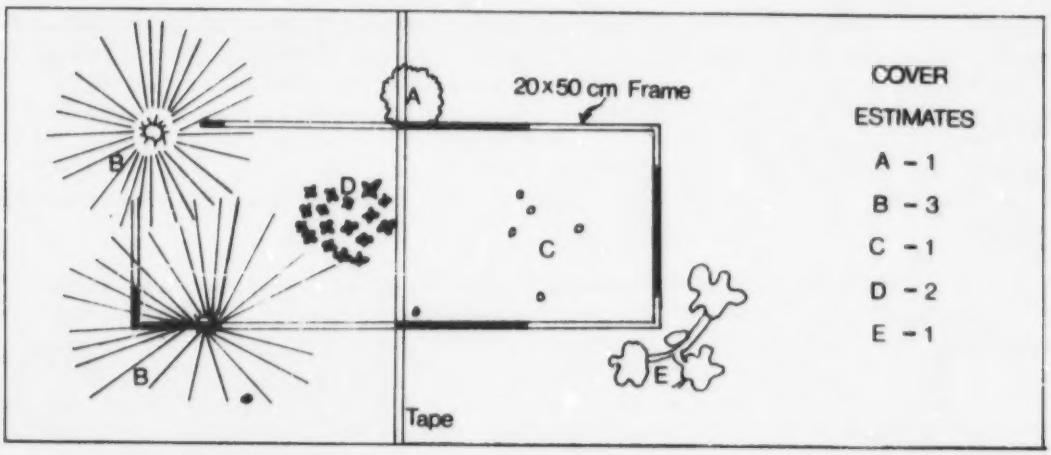


Figure 2. Diagram illustrating the method for estimating canopy coverage. The painted pattern on the X 20-- X 50- cm frame provides areas for visual comparison equal to 5, 25, 50 75 and 95 percent of the frame (After Demarchi 1971).

Table 2. Rating scale used to assess canopy coverage (from Daubenmire 1959).

Coverage class	Range of coverage (%)	Midpoint of coverage class (%)
1	0-5	2.5
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

On each transect, 20 quadrats were used to estimate canopy-cover. A tape was tied to the metal stakes at each end of the transect and at each sampling point, the frame was placed so it was divided in half crosswise (Fig. 2). At Placid Oil Mine, each transect was 30.5 m long and coverage measured at 1.5 m intervals. At McGillivray and Erickson each transect was 61 m long and coverage measured at 3.0 m intervals. Ground cover was also assessed, using the four corners of the quadrat, in 1975, at McGillivray and Erickson Pits, and in 1976, at all areas.

Annual yields of herbage were estimated for the resloped and seeded areas at Placid Oil, McGillivray Pit and Erickson Pit. These estimates were based on clipping unprotected vegetation in one sq m plots. In 1974, these clipping plots were located at 6.1 m intervals along the vegetation transects, 6.1 m above or below the transect. In 1975 and 1976, the clipping plots were located at 3.0 m intervals to double the sample size and so increase the precision of yield estimates. Different plots were clipped each year.

A rectangular frame was constructed using spikes and twine. It measured 50- x 200-cm, enclosing an area of 1 m^2. The spikes were driven into the ground, connected by twine, and all non-woody plants within the frame were clipped close to the ground. In 1974, clipped vegetation was not separated, but in 1975 and 1976 we clipped, dried and weighed grasses and forbs separately. Clippings from each plot were placed in numbered bags and stored open to the air to prevent moulding. They were later dried for 48 hours at 50 C, then weighed to the nearest gram.

HABITAT USE

Habitat use by ungulates was determined using four methods: counting pellet groups, recording and observing tracks, recording use (browsing) of vegetation, and documenting wildlife observations made by the authors and reliable individuals (see Appendix II).

Pellet group count

Data on pellet groups and tracks were gathered from parallel transects that ran through the reclaimed area and approximately 183 m or three stations into the surrounding, undistrubed vegetation. Transects were positioned diagonally uphill so as to include the greatest variation (Smith et al. 1969). We marked the starting points for transects with a 0.6 m metal stake driven into the ground, or

placed in a rock cairn. Stakes were unpainted at Placid Oil and painted yellow at McGillivray and Erickson Pits. All were flagged with blue and white flagging tape. Transects began along conspicuous, existing baselines, such as roadsides. They were spaced approximately 91 m apart at Placid Oil and Erickson Pit, and 122 m at McGillivray Pit.

Sampling was done at 61 m intervals along the transect (Figure 3). The first station along the transect was randomly chosen. In 1975, we marked each station more clearly by placing a rock cairn or wood stake in the centre plot. Flagging marked with the transect and station number was placed under the rock cairn or around the wooden stake. In 1976 the same stations were sampled.

Sampling at each station was done in five 9.3 m^2 circular plots (Figure 3). One plot was located at the station centre (end of the 61 m tape) with the other four 7.6 m away from the first plot, ahead and behind it along the transect, and on either side of the transect at right angles to the station (Figure 3). This 7.6 m was measured by pacing. In 1975 and again in 1976, we cleared the center plot of pellet groups to gain insight into deterioration rates.

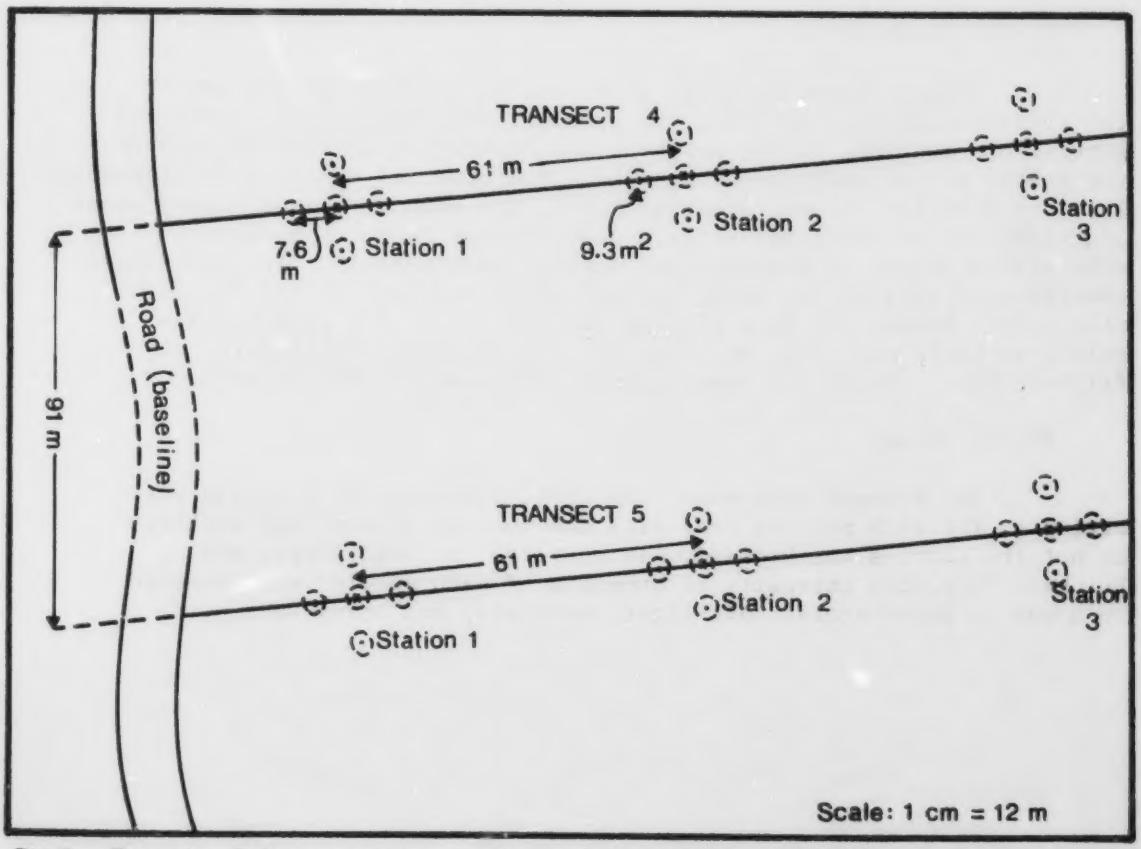


Fig.3. Example of the arrangement of transects, stations and plots.

Plot areas were determined by rotating a 1.7 m rod through 360°. Pellet groups were counted in each of the five plots. A pellet group was counted if over half of it fell within a plot.

In some areas, the same pellet group transects could not be followed because of recent disturbance by machines. In other areas, new transects were established to provide more comprehensive coverage. In 1977, we ran some of the transects at McGillivray and Erickson Pits only. Time prevented collecting data at the Placid Oil mine.

The vegetation-type of each station was noted to determine the average number of accumulated pellet groups per plot for each vegetation-type.

Track counts

Besides pellet groups, tracks also indicated wildlife use. In 1974, individual tracks were counted in each reclaimed plot at Placid Oil; in 1975 and 1976, we noted when tracks occurred in a plot at all areas. This way, we identified areas of greatest use based on number of plots that had tracks instead of by number of tracks in an area. We believed this revised method was more objective and convenient.

Direct observations

Direct observation was also used to indicate animal use of the reclaimed areas. In 1974, the species, sex, date, time, place and general observations on the movement and numbers of animals sighted in the course of the study were recorded. Personnel of Kaiser's Environmental Services Division and employees at Placid Oil mine were interviewed about sightings on the reclaimed sites. Also, Kaiser Security personnel submitted a record of animals seen during their patrols. In 1975, these observations were in the early spring (April and May) at the Placid Oil mine only. Because of lack of time and also lack of a good vantage point, we could not carry out observations at either McGillivray or Erickson Pits. No animal observations were made in 1976 or 1977.

Browse survey

Two methods were used. In 1974, frequency of browsing was estimated for each plot by recording the species present and whether or not the species was browsed. In addition, at McGillivray and Erickson Pits, the intensity of browsing of each species was assessed on a one to three scale: nil-light, moderate, and heavy-severe.

In 1975, this method was revised to gain better information on species preferences, on the availability of browse, on the intensity of browsing, and on plant vigor. For the revised browse survey, we adapted the methods of Cole (1967). For the intensity of browsing, we estimated leader use using the scale shown in Table 3. In each plot, we recorded estimated leader use for all plants of each species.

Table 3. Ratings used to estimate leader use and their percentage ranges (after Cole 1967).

Recorded estimates	Percentage ranges
0	No use
5	1-10
25	10-40
50	40-60
70	60-80
90	80-100

The availability of a shrub for browsing and plant vigor was determined by a form class rating scale (Table 4). Plant vigor was indicated by the degree of hedging. Browse occurring between zero and 2.4 m was considered as available to deer and elk.

Table 4. Form classes used to estimate browse availability and condition (after Cole 1967).

Number	Form class
1	all available, little or no hedging
2	all available, moderately hedged
3	all available, severely hedged
4	partly available, little or no hedging
5	partly available, moderately hedged
6	partly available, severely hedged
7	unavailable
8	dead

Hedging assignments were based on the length and appearance of the second year growth below current leaders. In the severely hedged condition, second year growth was relatively short and many terminal buds had been removed causing an abnormal growth form (Figure 4); in the moderate condition, second year growth was somewhat lengthened and only moderately altered from the normal growth pattern (Figure 4); and, in the little or no hedging condition, second year growth was only slightly altered or unaltered from normal growth (Figure 4).

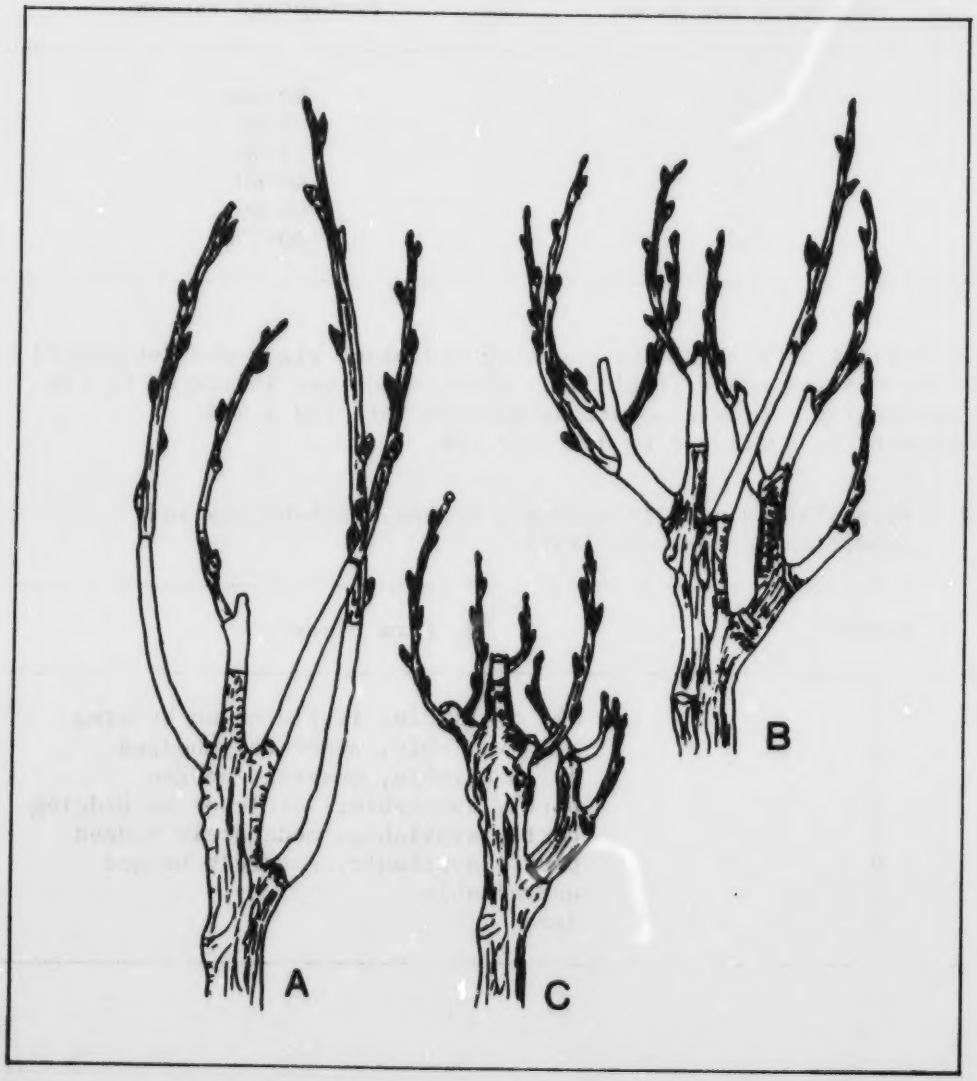


Fig. 4 . Degrees of hedging : A – zero to light; B – moderate; C – severe (After Cole 1967).

DATA ANALYSES

Differences in ungulate use between vegetation-types and between the three years were examined using the pellet group data. The mean number of accumulated pellet groups per plot were compared statistically using the Student's t-test and a 95 percent level of significance. In all cases, the null hypothesis was no significant differences between tested means.

Data on browse and browsing intensity were analyzed as follows. The frequency of occurrence of a browse species was expressed as a percentage of the plots in which the species occurred in a particular plant community. To determine the frequency of browsing on each shrub species, for each plot, we recorded the percentage of plants of that species that had been browsed. These individual plot percentages were averaged in a particular plant community to estimate mean percentage of plants browsed by species.

Canopy coverage was determined for each species recorded on the transects. For each species, coverage ratings were converted to the midpoint percentages shown in Table 2 and averaged for each plant community.

Differences in productivity estimates between vegetation-types and between years were compared using the Student's t-test (variances unknown, but assumed to be equal) and a 95 percent level of significance. As with the pellet group data, the null hypotheses were no significant differences between mean yields tested.

RESULTS AND DISCUSSION

PLACID OIL MINE

The vegetation-types

Seven communities were defined for the study area; four occurred on the undisturbed area surrounding the mine site, and three comprised all the disturbed area.

The four communities of the undisturbed area were characterized as follows (Table 5 and Figure 5):

1) waxberry-dogbane community: Shrubs 1-3 m tall dominated this community. The main shrub species were waxberry, saskatoon, bitterbrush, soopolallie, redstem ceanothus, rose and cherry.

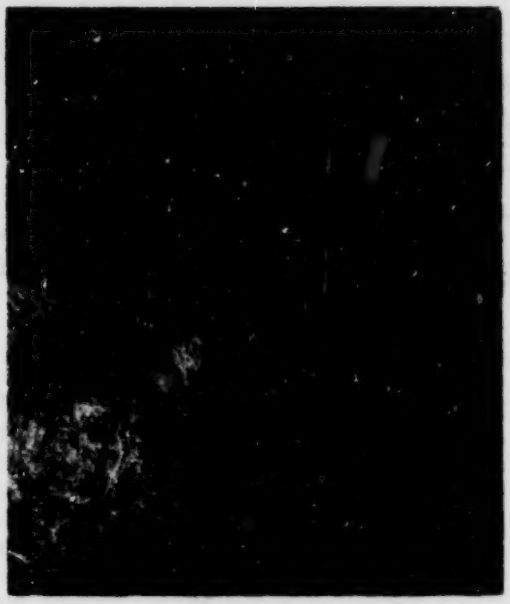
Willows occurred on the wetter sites. Shrub density and height varied over the map area so that two sub-types could be distinguished: a dense phase with shrubs mostly greater than 0.5 m tall; and an open phase with shrubs mostly less than 0.5 m tall. The commonest herbs were dogbane, aster, fireweed, yarrow, Canada bluegrass, downy brome, Kentucky bluegrass and timothy. A total of 47 species was recorded in sampling.

2) saskatoon-bluegrass: This community occurred mainly on the river terraces below the reclaimed area (Figure 5). Canada and Kentucky bluegrasses were the commonest species, with saskatoon having the next highest coverage. Less common were bitterbrush, waxberry, pussytoes, yarrow and Richardson's needlegrass (Table 5). A total of 32 species were recorded during sampling.

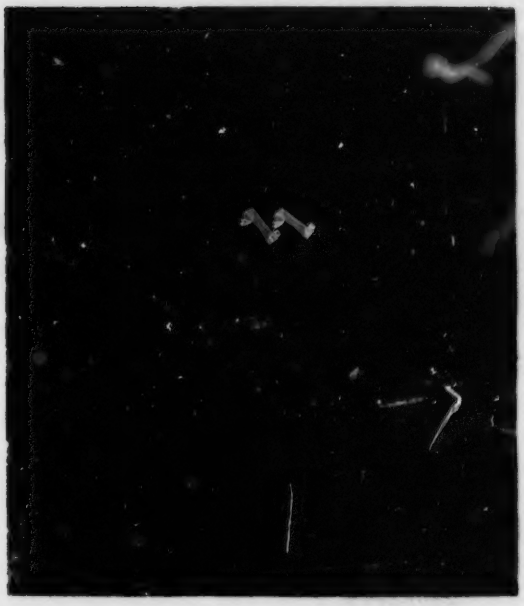
3) deciduous groves (maple-waxberry and aspen-waxberry): Scattered throughout the two above communities were small groves of deciduous trees and tall shrubs, (Figures 5 and 6). Maple-birch patches occurred along creeks and in swales. Common species in the understory were creeping mahonia, thimbleberry, waxberry, arnica and pinegrass (Table 5). A total of 29 species were noted in these groves. Small groves of aspen grew on the drier sites. Common understory species were cherry, creeping mahonia, saskatoon, waxberry and pinegrass. Twenty-two species occurred in the sample quadrats.

4) conifer groves: These were scattered over the study area but were not studied since they were small, variable and uncommon (Figure 6). The commonest tree species were Douglas fir and ponderosa pine.

In addition to these four major communities were small patches of other types, e.g. the Douglas fir - wheatgrass communities. These were omitted due to their small size and scattered occurrence.

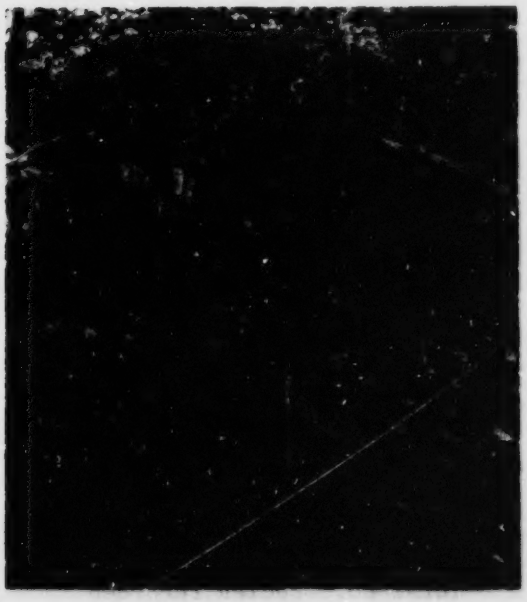


waxberry-dogbane



saskatoon-bluegrass

deciduous grove
(maple-waxberry)



deciduous grove
(aspen-waxberry)

Figure 5. Undisturbed plant communities at the Placid Oil study area.

Table 5. Percent canopy coverage of major plant species in the four undisturbed communities at the Placid Oil mine.*

Species	Canopy Coverage			
	waxberry-dogbane	saskatoon-bluegrass	maple-waxberry	aspen-waxberry
TREES AND SHRUBS				
Bitterbrush	7	6	-	-
Cherry	5	-	1	13
Creeping mahonia	8	1	20	14
Redstem ceanothus	7	-	-	4
Rose	3	4	6	1
Saskatoon	17	12	6	15
Soopolallie	5	4	4	6
Thimbleberry	1	-	19	1
Waxberry	23	6	25	39
FORBS				
Arnica	1	1	10	1
Aster	6	-	2	3
Dogbane	19	1	1	6
Fireweed	5	-	-	-
Pussytoes	1	6	-	2
Yarrow	6	6	-	-
GRASSES				
Beardless wheatgrass	5	-	-	-
Canada bluegrass	7	25	1	1
Cowny brome	8	1	-	-
Kentucky bluegrass	7	28	1	-
Pinegrass	4	-	8	32
Poverty oatgrass	11	3	-	5
Richardson's needlegrass	-	6	-	-
Timothy	8	2	-	-
No. of species with > 5% cover	24	18	15	16
Total no. species recorded	39	32	29	22
No. transects**	6	2	2	2

* Only species with greater than 5% cover are listed; complete lists of species for each community are given in Appendix IV.

** 20 quadrats per transect.

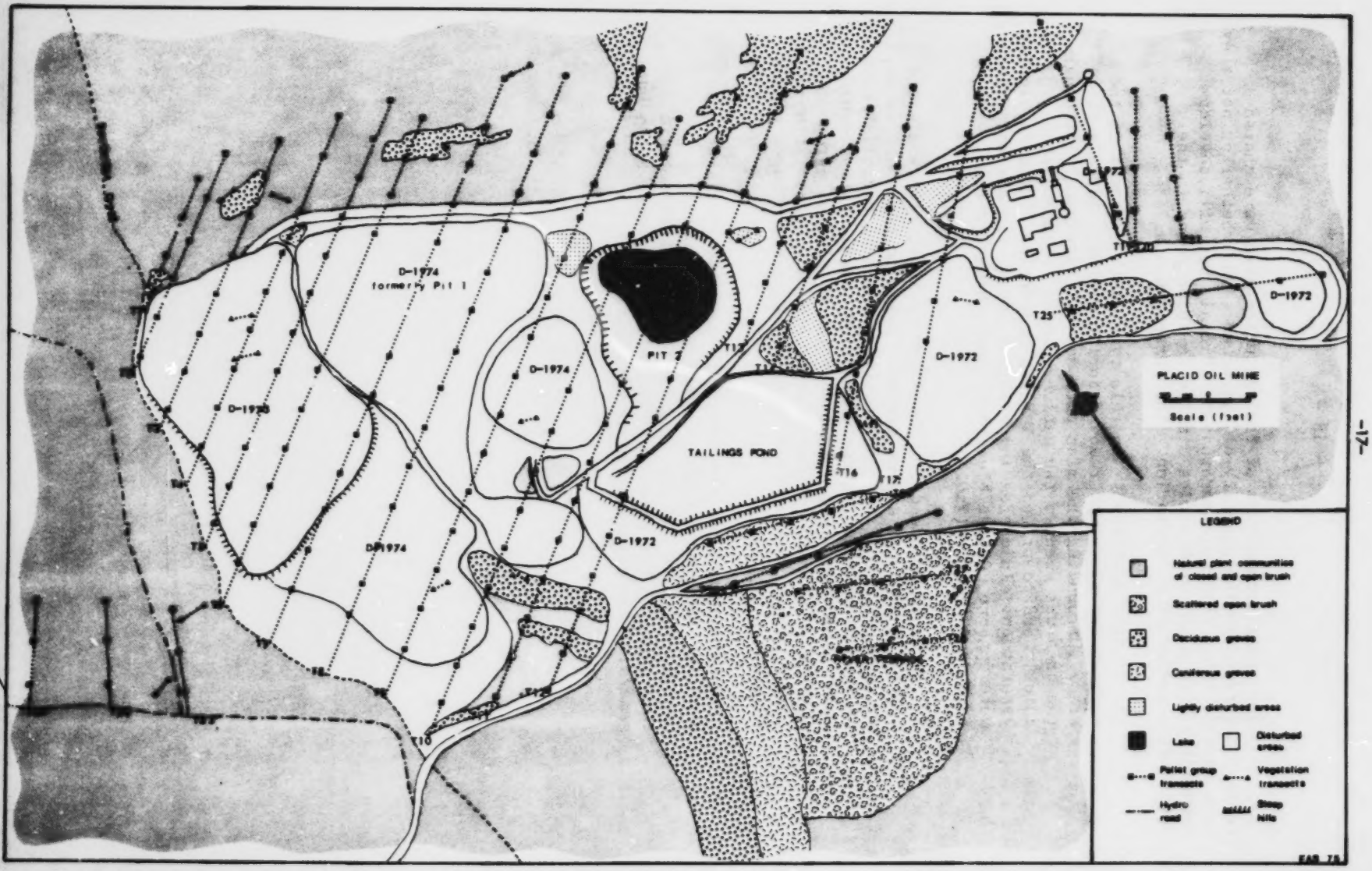


Fig. 6. Map of the transects and plant communities at the Placid Oil mine.

The three communities of the disturbed area were characterized according to the severity of disturbance and whether or not they were seeded. Thus they were somewhat artificial, but will develop eventually into plant communities similar to those found in the surrounding undisturbed vegetation. The three types are:

1) lightly disturbed: In this type, a thin veneer of the surface materials was removed during mining - largely in areas surrounding the mine pits and tailings pond. Although the area was seeded, the native species re-established quickly and comprised the largest proportion of the developing vegetation. In decreasing order of cover, the six main species were dogbane, Canada bluegrass, downy brome, yarrow, waxberry and timothy (Table 6).

2) resloped and seeded: This type included reworked waste materials produced during mining. Soil, in the usual sense, was non-existent. Very few native species re-established themselves on these severely modified areas. Rather, the plant cover consisted almost entirely of planted agronomic species. The main species were crested wheatgrass, timothy, alsike clover, tall fescue, tall wheatgrass and sweet clover (Table 6).

3) resloped and not seeded: This type was similar to the previous one except that no seeding had occurred. Consequently, we did not do any vegetation transects in this type. A few great mullein had invaded local sites but generally the area was devoid of vegetation.

Table 6. Percent canopy coverage of major plant species on the disturbed area at the Placid Oil mine, 1974-76.*

Species	Planted in 1972			Planted in 1973			Planted in 1974			Lightly disturbed		
	1974	1975	1976+	1974	1975	1976	1974	1975	1976	1974	1975	1976
SHRUBS												
Black cottonwood	1	9		-	-	-	-	-	-	-	-	-
Saskatoon	-	-		-	-	-	-	-	-	2	4	7
Waxberry	-	-		-	-	-	-	-	-	9	5	6
FORBS												
Alsike Clover**	-	-		2	1	6	11	5	19	-	1	3
Black Medic	12	3		-	-	-	-	-	-	6	1	5
Dogbane	-	-		-	-	-	-	-	-	27	15	15
Great mullein	-	1		1	-	-	1	<1	<1	6	2	<1
Sweet clover**	2	1		4	-	-	-	19	-	-	3	2
Yarrow	-	-		-	-	-	-	-	-	9	6	7
GRASSES												
Bearded wheatgrass**	-	-		-	-	-	18	-	-	-	-	8
Canada bluegrass**	11	7		-	<1	<1	-	-	<1	19	11	21
Crested wheatgrass**	23	3		14	9	3	23	14	16	-	2	<1
Downy brome	2	1		-	-	-	2	<1	<1	22	1	7
Intermediate wheatgrass**	-	6		-	1	-	-	-	<1	-	4	-
Kentucky bluegrass	-	-		-	-	-	-	-	-	9	-	-
Slender wheatgrass**	13	-		8	-	-	-	1	-	-	-	-
Tall fescue**	1	-		16	13	5	3	2	4	-	-	1
Tall wheatgrass**	1	15		3	<1	-	2	7	<1	-	1	-
Timothy**	16	15		17	12	4	7	3	13	7	3	10
Total no. species recorded	17	15		9	7	5	10	11	10	28	28	29
No. transects++		2			2			2			2	

* Only species with >5% cover are listed; complete lists are given in Appendix V.
** Species planted on the overburden.
+ Not sampled
++ 20 quadrats per transect

Table 7. Forage yields of seeded vegetation at the Placid Oil mine, 1974-76.

Year seeded	Year sampled	Sample size	Oven dried yields in g/m^2 (± SD) total	grasses	forbs
1972	1974	10	127±120	-*	-
1973	1974	10	23±17	-	-
	1975	20	15±11 **	15±10	1
	1976	20	17±22+	10± 8	6±20
1974	1974	10	28±20	ns	ns
	1975	20	64±53	19±12	45±51
	1976	20	79±81	37±38	42±54

* In 1974, grasses and forbs were not separated.
** There is a significant difference in the 1975 clip between areas seeded in 1973 and those seeded in 1974
\+ There is a significant difference in the 1976 clip between areas seeded in 1973 and those seeded in 1974.

Assessment of revegetation

The success of revegetation on the disturbed area was assessed by annual yield, ground cover, species composition and cover. Yields were highly variable (Table 7). The yield of areas seeded in 1972 was measured once in 1974 when 127 g/m^2 was produced (Table 7). This estimate was atypically high since the sampling area was found to be receiving extra water and nutrients from a broken sewer pipe. These data are not discussed further.

The areas seeded in 1973 and 1974 were viewed as representing typical yield responses (Table 7). Even so, yields were variable - a reflection of the uneven growth over the disturbed minesite. For the areas seeded in 1973, yields were comparatively low during the sampling period. The average yield was 18±4 g/m^2, and consisted mainly of the agronomic grasses, crested wheatgrass, tall fescue and timothy. Rather than increasing production over years, yields appeared to decline. For the areas seeded in 1974, yields averaged 57±26 g/m^2 during the three years, and were significantly higher than the 1973 seeded area in both 1975 and 1976 (Table 7). The herbage consisted mostly of forbs (61%), especially alsike and sweet clovers. Crested wheatgrass and timothy were the major grasses in the clipped herbage.

The different yield responses between the areas seeded in 1973 and 1974 probably resulted from site-related differences such as moisture supply (some of the areas seeded in 1974 had a higher moisture supply than those seeded in 1973) and seed-bed preparation that could enhance yields.

Although the results are only for a short period after seeding, they do demonstrate that yield responses vary widely. A clear explanation for these variations would provide useful information on achieving optimum growth (and therefore more successful establishment) of vegetation.

Yields of seeded vegetation were mostly below those of the undisturbed communities. For example, the waxberry-dogbane community produced an average of 76 g/m^2 during the four years 1967-1970 (unpublished data on file, Wildlife Research Section, Victoria, B.C.). During the same period, the saskatoon-bluegrass type had a mean yield of 55 g/m^2. Although the yields from the disturbed and undisturbed communities are not contemporaneous, the relative differences still probably apply. Only the 1975 and 1976 yields from the area seeded in 1974 had similar production to natural vegetation types.

Ground cover also varied between the three disturbed communities. These differences between the two seeded areas were positively associated with forage production. In the 1976 sampling, the area seeded in 1973 had only 9% plant cover compared with the area seeded in 1974 which had 20% plant cover (Table 7).

Table 8. Percent ground cover of Placid Oil Mine, August 1976.

Sample area (n)	Ground cover (%)				
	rock	plant	ground	litter	cryptogams
Seeded 1973 (160)	88	9	4	-	-
Seeded 1974 (160)	49	20	21	6	4
Lightly disturbed (160)	7	58	27	9	-

The third criteria for assessing revegetation was plant species composition (Table 6 and Appendix V). The criterion that we assumed was that increasing species diversity and increasing proportions of native species would lead to a viable vegetative cover. However, except for the lightly disturbed type, the resloped communities had 70% fewer species than the undisturbed communities. The atypical area planted in 1972 had 17 species, but the area planted in 1973 and 1974 had 9 and 10 species, respectively. Compared with this, the lightly disturbed type had 29 species and the undisturbed types had from 22 to 47 species (Table 5). Additionally, the limited data indicated a downward trend in species diversity for the resloped areas.

Native species were rare on the resloped areas except for the lightly disturbed type (Table 6). Great mullein occurred occasionally on the perimeters of the areas, and black cottonwood established on the site where sewage had leaked out. Although these reclaimed areas were disturbed relatively recently, we expected more colonization by natives than encountered. Many native pioneer species are aggressive competitors and produce abundant, easily dispersed seed. Their failure to establish on the mine site reflects the relatively adverse growing environment. Thus our observations of declining species diversity and a low rate of colonization by natives is not an encouraging prognosis for the establishment of a viable vegetative cover.

Trends in plant cover were also not encouraging (Table 6). Only three of the 11 agronomic species planted, alsike clover, timothy and crested wheatgrass, maintained coverage on at least one of the seeded areas. However, these and most other agronomics showed declining cover. For example, crested wheatgrass declined from 14% to 3% coverage between 1974 and 1976; timothy declined from 17% to 4%. Annuals such as black medic showed wide annual differences.

The profound effect of degree of disturbance in the subsequent plant community is illustrated by comparisons between the resloped and lightly disturbed parts of the minesite (Table 6). The latter area supported the most species in total, the most native species and showed the least annual variations in canopy-coverage. Obviously, not all of a minesite can be only "lightly" disturbed, but our results show the value of minimizing the area of severe disturbance or of using at least small amounts of topsoil in reclamation.

The differences between resloped and seeded areas is shown by photographs taken in the summers of 1974 and 1976 (Figure 7). The area seeded in 1972 had a lush appearance in both 1974 and 1976 due to the extra supply of water and nutrients. Photographs of the areas seeded in 1973 and 1974 show the patchy plant growth over the disturbed minesite and illustrate the relatively few changes in plant cover that occurred on the seeded areas during the study period. These photographs contrast remarkably with corresponding ones for the lightly disturbed area.

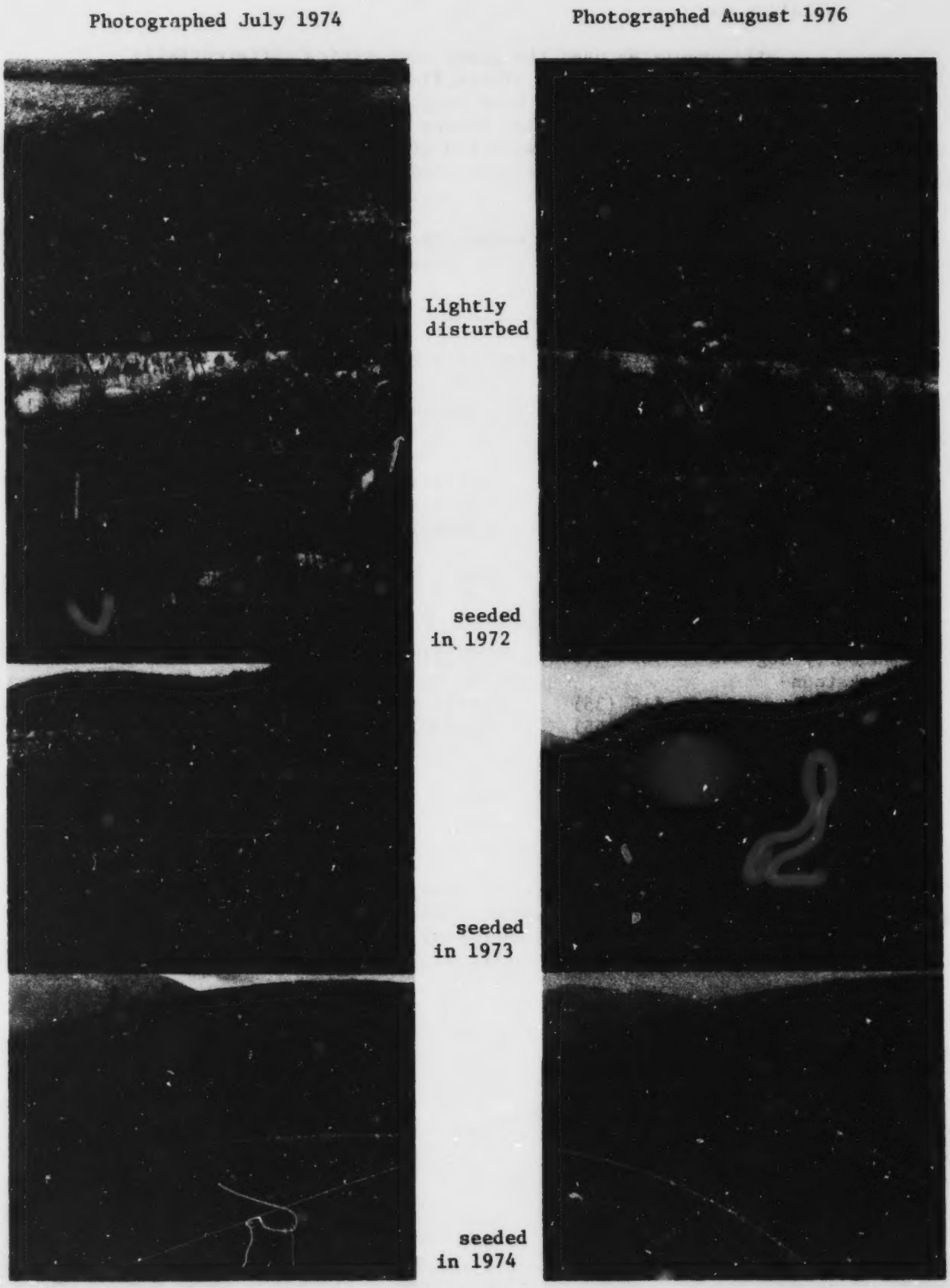


Figure 7. Comparisons of lightly disturbed areas, areas seeded in 1972, 1973, and 1974 and photographed in 1974 and 1976.

Wildlife use

Wild ungulates used the plant communities differentially during the three years of study (Table 9). Lightly disturbed areas within the minesite were always used most heavily, with three-year average of 1126 accumulated pellet groups /ha. The resloped and seeded areas ranked second with 460 groups /ha, while the resloped and not seeded portions were used least with 171 groups /ha.

Table 9. Relative use of plant communities by wild ungulates at the Placid Oil mine, 1974 - 76, based on pellet group counts.

Plant community	Accumulated pellet groups per hectare 1974	1975	1976	Means (3 yr.)
Disturbed				
Seeded	52(430)++	586(415)	741*(308)	460
Not seeded	0(60)	20+(55)	494*(24)	171
Lightly disturbed	430(125)	1216(85)	1732*(56)	1126
Mean for disturbed	161	607	989	586
Undisturbed				
Waxberry-dogbane	3025**(360)	2397(395)	2528(316)	2650
Saskatoon-bluegrass	1198(35)	1599(35)	1534(28)	1444
Groves	1154(55)	1075(50)	754(40)	994
Mean for undisturbed	1792	1690	1605	1696

\+ 1975 results significantly higher than 1974 results.
* 1976 results significantly higher than 1974 results.
** 1974 results significantly higher than 1975 and 1976 results.
++ Number of 9.3m^2 plots in parentheses.

Ungulate use of the disturbed area increased steadily between 1974 and 1976 (Table 9). Use of the lightly disturbed portions increased fourfold from 430 to 1732 groups /ha. For the corresponding period, the resloped and seeded area increased 14-fold, while the resloped and unseeded area rose from no use to 494 groups /ha. Thus the rate of increase in use was greatest for the resloped but unseeded areas, intermediate for resloped and seeded areas, and least for lightly disturbed areas.

Changes in plant cover and degree of human disturbance were probably the main factors affecting use patterns on the disturbed area. The sharp increase in use between 1974 and 1975 probably resulted from the reduced human activity associated with closing the mine. (The degree of disturbance on the minesite may also explain the high use recorded in the adjacent waxberry-dogbane community, and the significant drop in the following year (Table 9)). The differences in use between the three types of reclamation paralleled their differences in plant cover, and probably production of forage. Thus the unseeded areas with little plant cover had the least use, while lightly disturbed areas with the greatest cover had the most use. The results demonstrate the value of vegetative cover in attracting ungulates onto resloped minesites.

Relative use of natural plant communities differed remarkably from that in the disturbed types. Overall use was three times greater, based on average pellet group counts during the three years and for all communities (Table 9). The waxberry-dogbane type was the most heavily used one on the entire study area. The saskatoon-bluegrass, and the deciduous and coniferous groves were used at levels from one-third to one-half of those recorded in the waxberry-dogbane community, but still exceeded use in all disturbed types except lightly disturbed.

Unlike the disturbed areas, use in the natural communities did not increase annually. Use varied from 14% to 24% of the three year means in the undisturbed communities. Only in the waxberry-dogbane type was the use in 1974 significantly higher than in the following two years. Moreover, changes in use level were not synchronous between these vegetation types.

Use patterns in the natural vegetation-types were probably due to several other factors in addition to plant cover and human disturbance. The waxberry-dogbane type had a wide variety of palatable food species, was tall enough to provide cover (hiding places), and was mostly situated away from roads and other areas of human activity. The saskatoon-bluegrass type was used by cattle, contained comparatively little cover, and was dissected by roads. The coniferous and deciduous groves were used least, presumably because they were quite dense, very small, and provided very little forage.

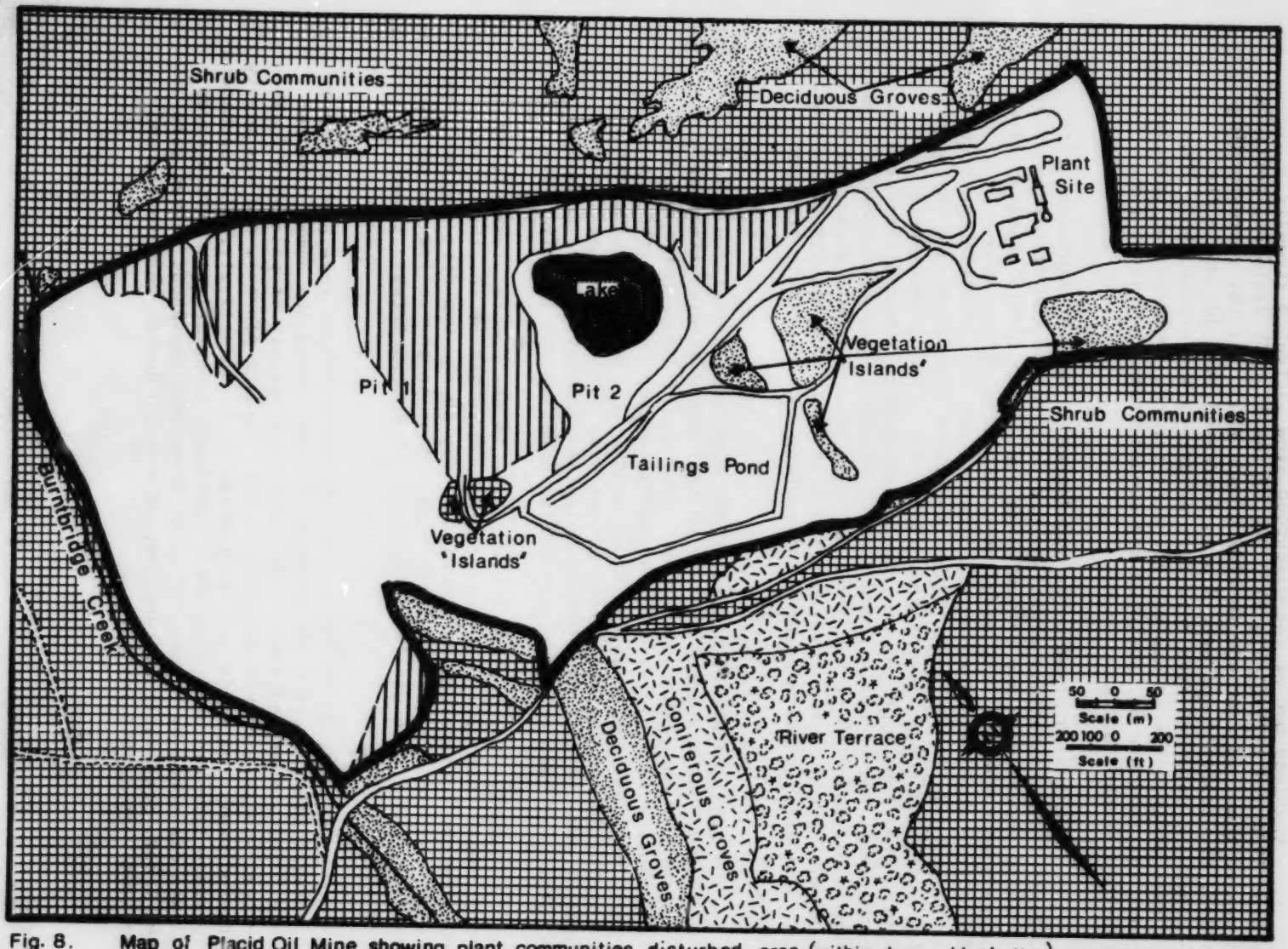


Fig. 8. Map of Placid Oil Mine showing plant communities, disturbed area (within heavy black line) and areas of highest ungulate use on the reclaimed sites (▥).

The "islands" of natural vegetation (deciduous groves) remaining in the disturbed areas were exceptions. They were used heavily, especially compared to the surrounding reclaimed area. We frequently observed deer and their tracks around these thickets of vegetation. The pellet group data for the disturbed area supported our observations (Figure 8). The areas closest to cover and to the "islands" tended to receive the heaviest use. We interpret this pattern as a consequence of the need for "security" cover by deer and elk.

Shrub species varied in their abundance, availability and utilization by wild ungulates (Table 10). Saskatoon was the most frequently occurring shrub. Ninety-nine percent of the time an estimated 44% of the leader shoots of this species were browsed. Over half of the saskatoon plants had all their twigs available for ungulate use and 32% of these plants had been moderately hedged. Chokecherry was the second most abundant species, but was not heavily browsed. The preferred browse species appeared to be redstem ceanothus. Ranking third in abundance, all the plants found in the plots had been intensively browsed and 97% of them had been severely hedged. Other frequently browsed species were bitterbrush (97%) and Douglas maple (94%). Their estimated intensities of browsing, however, were less than saskatoon and redstem ceanothus. Willow was not frequently browsed or as abundant as the above species but it was intensively browsed when it was available.

Table 10. Frequency and intensity of browsing and condition of shrub species in the undisturbed plant communities at the Placid Oil mine, 1975.*

Species	Abundance (ranked)**	Frequency of browse within plots (%)	Average intensity of browse (%)	Form class (%)						
				1	2	3	4	5	6	7
Saskatoon	1	99	44	100	-	-	-	-	-	-
Chokecherry	2	95	27	32	32	15	7	11	1	1
Redstem ceanothus	3	100	87	1	1	97	-	-	-	-
Waxberry	4	5	1	100	-	-	-	-	-	-
Soopolallie	5	19	1	99	-	-	1	-	-	-
Trembling aspen	6	47	15	14	11	1	23	9	-	41
Willow	7	72	41	5	9	1	13	33	13	24
Douglas maple	8	94	38	27	27	13	15	13	3	-
Bitterbrush	9	97	9	76	18	-	5	-	-	-
Rose	10	65	10	71	15	3	3	3	-	3

* Only the ten most frequently browsed species are listed; a complete list is given in Appendix VI.

** Ranked according to percent occurrence in 470-9.3 m^2 plots of species in the undisturbed communities.

McGILLIVARY PIT

The vegetation types

Four plant communities were defined for the McGillivary Pit study area: reclaimed, open or spirea-fescue, immature forest or pine-spirea-pinegrass, and mature forest or pine-thimbleberry-pinegrass (Figure 9). These can be described as follows:

1) reclaimed: McGillivary was an old mine that was reworked by Kaiser Resources Ltd. and then subsequently resloped with overburden. The area was planted in 1973 with trees, forbs and grasses (see Appendix III for planted species). The main species found in this type were alfalfa, sweet clover, creeping red fescue and ryegrass. The woody plants, black cottonwood, Douglas fir, European white birch, lodgepole pine and aspen were planted but not encountered in sampling.

2) open (spirea-fescue): The open type occurred above the reclaimed area (Figure 9). It was burned in the 1940's but conifers have not re-established. It is an area of scattered shrubs 0.9 to 1.2 m tall, consisting mostly of Douglas maple, with lesser amounts of saskatoon and soopolallie. There are scattered conifers and tall snags as well as groves of trembling aspen and of conifers (Figure 10). Ground cover is grasses and forbs, and some exposed bedrock (Table 11). Predominanat species included flat-top spiraea, Scouler's penstemon, rough fescue and pinegrass; common forbs included willow-herb, blue-eyed Mary, oval-leaf alumroot, pussytoes and strawberry (Table 11 and Appendix IV).

3) immature forest (pine-spirea-pinegrass): This community had an even-aged tree layer of lodgepole pine and occured on relatively dry sites. The canopy was closed. In the shrub stratum, dwarf huckleberry, spirea, grouseberry and soopolallie were common. The scattered presence of two m white spruce indicated a succession to a white spruce forest. In the herb layer, common species were pinegrass, arnica and aster. Typical of dense pine stands, the understory was poorly developed.

4) mature forest (pine-thimbleberry-pinegrass): The closed mature forest was also a stand of approximately equal-aged trees, but occurred in more mesic conditions. Predominant trees were lodgepole pine, larch and white spruce. The understory had more shrubs than the lodgepole pine forest probably because it was more open; the shrubs were generally about 1.5 m high (Figure 10). Predominant species were pinegrass, flat-top spirea, soopolallie, aster and thimbleberry. Other common species were arnica and thin-leaf alder (Table 11).

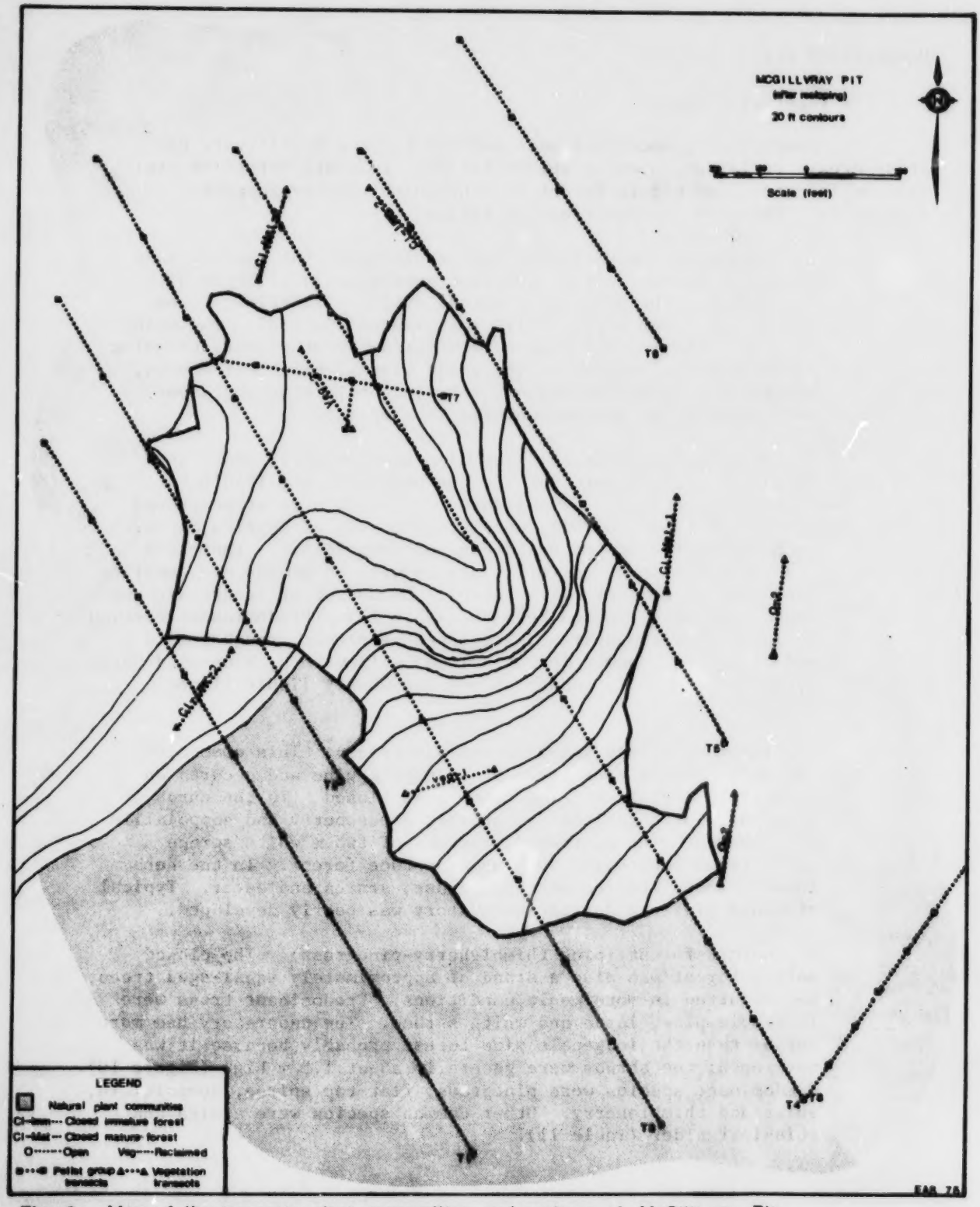
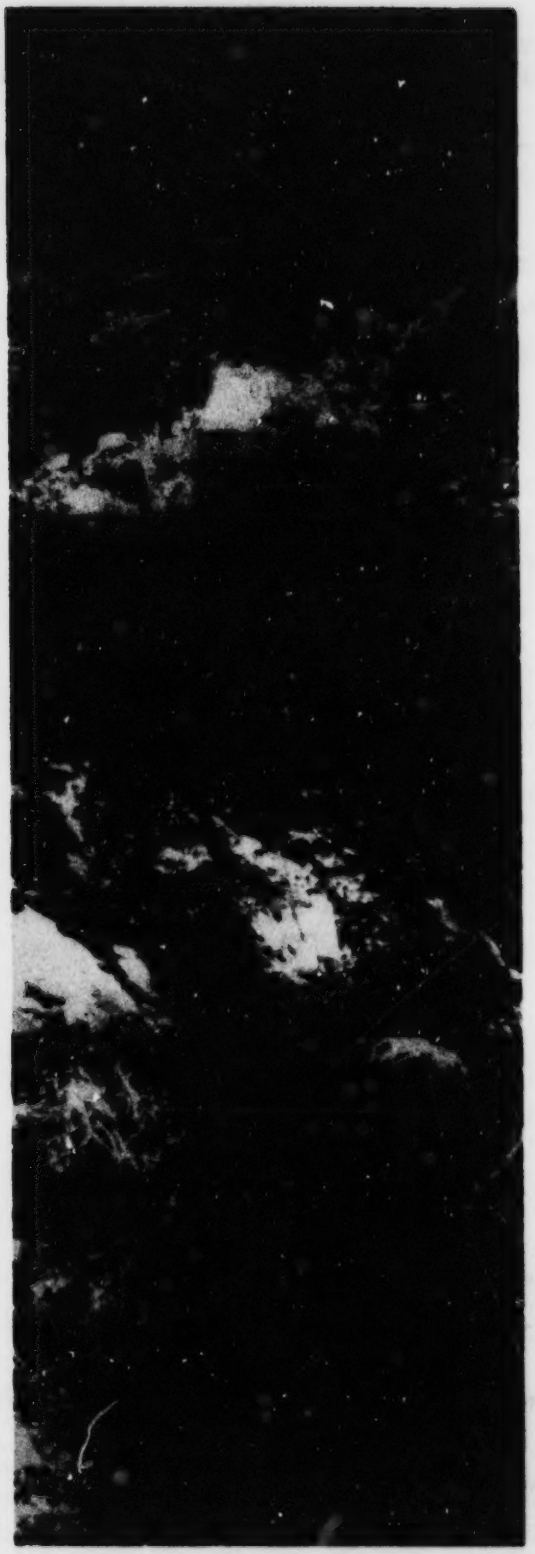


Fig. 9. Map of the transects, plant communities and contours of McGillivray Pit.



open
(spirea-fescue)

immature forest
(pine-spirea-
pinegrass)

mature forest
(pine-thimbleberry-
pinegrass)

Figure 10. Undisturbed plant communities at the McGillivary Pit study area.

Table 11. Percent canopy-coverage of major plant species recorded in the three undisturbed communities at McGillivray Pit, July 1974.

Species*	Percent canopy-coverage		
	open	immature forest	mature forest
TREES AND SHRUBS			
Dwarf huckleberry	-	8	-
Flat-top spirea	19	18	23
Grouseberry	-	9	<1
Red twinberry	3	2	6
Saskatoon	6	-	-
Soopolallie	-	9	23
Thimbleberry	-	5	15
Thinleaf alder	-	3	7
Twinflower	-	14	3
FORBS			
Arnica	<1	6	13
Aster	<1	7	17
Columbine	-	-	7
Oval-leaf alumroot	6	-	-
Scouler's penstemon	11	-	-
Blue-eyed Mary	6	-	<1
Fireweed			
GRASSES			
Pinegrass	9	43	33
Rough fescue	13	-	-
Timothy	<1	-	-
No. of species with > 5% cover	11	11	12
Total no. species recorded	35	19	31
No. transects**	2	2	2

* Only species with greater than 5% cover are listed; complete lists of species in each community are given in Appendix IV.

** 20 quadrats per transect.

Assessment of revegetation

Growth of vegetation at McGillivray was lush, reflecting the heavy annual application of nitrogenous fertilizer (228 kg/ha). Annual yields, at 242±42 g/m^2, did not vary significantly between years (Table 12). Although yield data were variable (CV = 50%), they were much less so than at the Placid Oil area (CV = 90%). The relative proportions of grasses and forbs varied between 1975 and 1976, the two years in which these components were separated. It may be that the forbs, primarily alfalfa and sweet clover, were more successful competitors for light and nutrients than the grasses. As these legumes are not long-lived, any supression of grass is likely temporary.

Table 12. Forage yields of seeded vegetation at McGillivray Pit, 1974-76.

Year sampled	Sample size	Yield (oven dry wt. in g/m^2) (mean ± S.D.) total	grasses	forbs
1974	10	197±99	- *	-
1975	20	279±163	150±75	129±163
1976	18	250±102	71±38	178±80

* samples not separated into grass and forb components.

Table 13. Changes in percent canopy-cover of plant species on the seeded area at McGillivray Pit, 1974-76*.

Species	Canopy-cover (%) 1974	1975	1976
FORBS			
Alfalfa	37	25	38
Sweet clover	45	3	13
GRASSES			
Canada bluegrass	1	9	9
Creeping red fescue	18	8	26
Crested wheatgrass	11	3	2
Intermediate wheatgrass	9	1	1
Ryegrass	27	15	-
Slender wheatgrass	6	1	-
Smooth brome	5	1	3
Timothy	16	9	8
Total no. species recorded	13	12	9
No. transects++	2	2	2

* Only species with greater than 5% cover are listed, complete lists are given in Appendix V.
** Planted species on the overburden
++ 20 quadrats per transects.

Photographed
July, 1974

Photographed
July, 1975

Photographed
August, 1976

Figure 11. Annual changes in seeded vegetation at McGillivary Pit, 1974-76 (seeded in 1973).

Plant species diversity showed a downward trend during the 1974-76 period (Table 13). Also, native species were absent on the reclaimed area. In these two respects, Placid Oil and McGillivray Pit were similar. However, the absence of natives at McGillivray was probably due to the dense vegetative cover.

Plant cover also changed markedly (Table 13). In all years, alfalfa was the dominant species. Sweet clover, the wheatgrasses and timothy showed declines in cover, while Canada bluegrass and creeping red fescue increased. These latter two species appeared to be most promising in establishing a viable vegetative cover.

Compared with Placid Oil, the vegetation appeared better established. However, this was most likely due to a better moisture regime and the application of fertilizers. Judged on the basis of species diversity and invasion of native species, the successful revegetation of McGillivray Pit is not as promising as the yield data indicate. The real test of success will be when fertilization is stopped.

Wildlife use

Use varied among plant communities and between years (Table 14). In the reclaimed community, use increased 10-times during the 1974-1977 period, and during the last two years no significant differences occurred in use between the reclaimed and the open types. In the undisturbed communities, the pine forests were used at one-half to one-third the levels recorded in the open type. Over the four years, use in the forest increased by almost 100%. Use in the open spirea-fescue type consistently declined but the annual differences were not significant.

Table 14. Relative use of plant communities by ungulates at McGillivray Pit, 1974-77, based on pellet group counts.

Plant community	Accumulated pellet groups per hectare				Means (4 yr)
	1974	1975	1976	1977	
Disturbed					
Reclaimed	151(120)*	484+(115)	1470+(92)	1437(88)	886
Undisturbed					
Closed forest	425(200)	511(160)	773+(128)	839(52)	637
Open	1680(45)	1646(60)	1525(48)	1448(40)	1575
Mean for undisturbed	1052	1079	1149	1144	1106

* Number of 9.3m^2 plots in parentheses.
\+ Significantly different from the previous year's data.

Heaviest use of the reclaimed area occured near cover at the bottom and at the top of the slope (Figure 12). Less use occurred where haul roads entered the reclaimed area, or where exploration roads abutted the reclaimed area. Tracks were recorded on the reclaimed area but because of the lush vegetation and rough terrain, they could not be considered as a valid indication of animal use. Within the undisturbed plant communities, heaviest use was on the open slope above the reclaimed site.

Elk were the predominant ungulate species found on the reclaimed area of McGillivray Pit, with 85% of the pellet groups counted, followed by deer (14%) and moose ($<1\%$).

In the natural plant communities, the most frequently occurring shrubs were soopolallie and flat-top spirea. These two species, however, were not very palatable as their frequencies of browsing were 32% and 5%, respectively (Table 15). Willow was by far the most frequently browsed shrub as well as the most intensively browsed - 53% of the plants found were severely hedged (Table 15). Douglas maple, trembling aspen and black cottonwood were also preferred browse species (Table 15).

In the reclaimed area, willow was again the most popular browse shrub, followed by thimbleberry. The palatable planted shrubs such as black cottonwood and trembling aspen were usually uprooted where animals had tried to browse them. In many cases these shrubs were covered and surrounded by the very lush growth of alfalfa and sweet clover, and, in fact, were becoming chlorotic because of a lack of light.

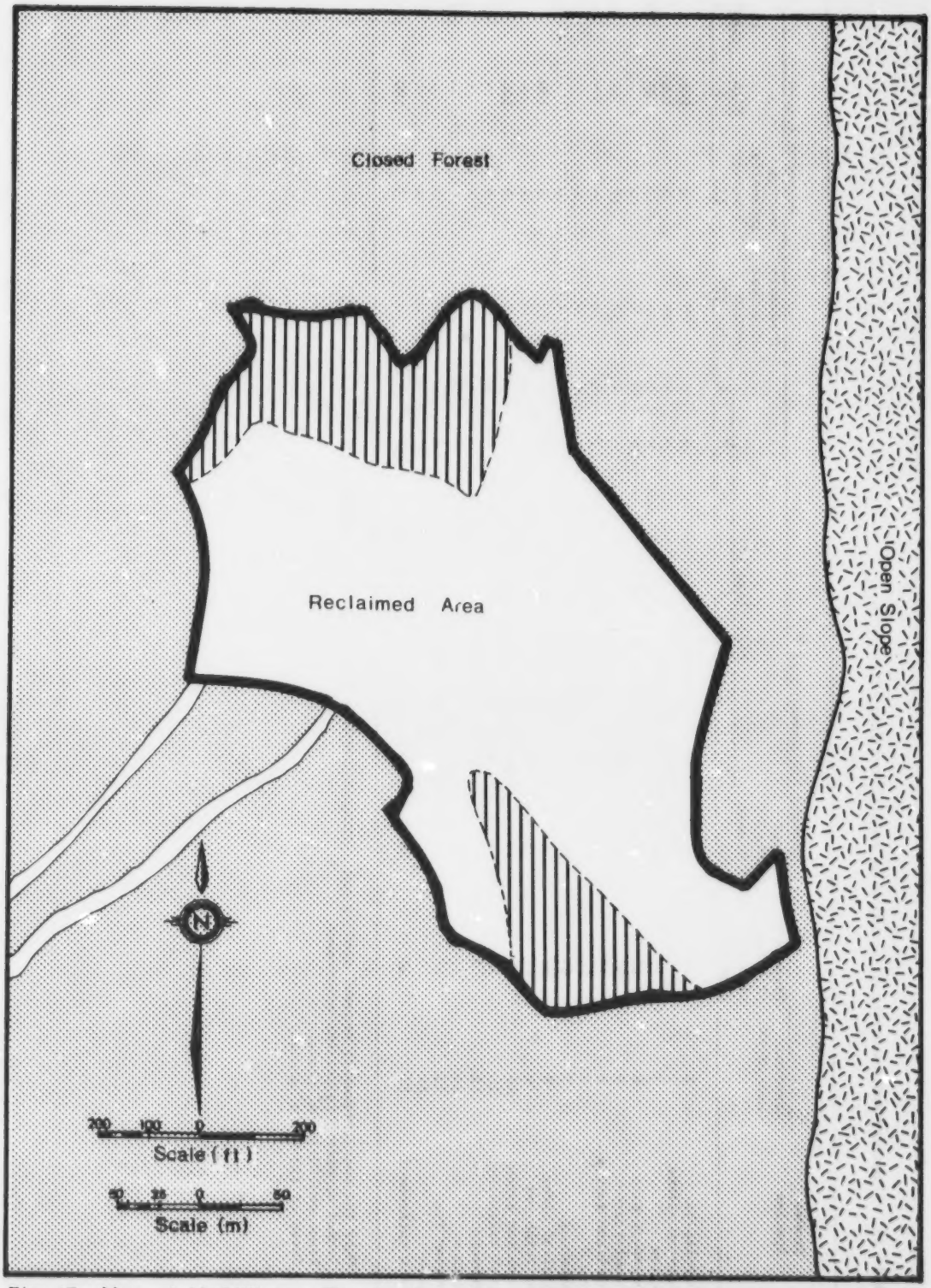


Fig. 12. Map of McGillivray Pit showing plant communities, reclaimed area and areas of heaviest ungulate use on the reclaimed sites ( ).

Table 15. Frequency and intensity of browsing on McGillivray Pit, 1975*.

Browse Species	Undisturbed communities +											Reseeded Area++			
	Abundance (ranked)**	Frequency of browse within plot (%)	Average intensity of browse (%)	Form class (%)								Frequency of browse within plot (%)	Average intensity of browse (%)	Form class (%)	
				1	2	3	4	5	6	7	8			1	2
Soopolallie	1	32	2	98	-	-	1	-	-	-	-	0	0	100	-
Flat-top spirea	2	5	1	100	-	-	-	-	-	-	-	14	3	100	-
Willow	3	11	63	13	10	53	1	3	13	-	6	100	43	25	75
Lodgepole pine	4	11	1	-	-	-	21	-	-	79	-	-	-	-	-
Thimbleberry	5	37	5	91	9	-	-	-	-	-	-	67	17	67	33
Engelmann spruce	6	23	1	11	-	-	81	-	-	7	-	-	-	-	-
Rose	7	29	5	95	5	-	-	-	-	-	-	-	-	-	-
Saskatoon	7	93	20	61	37	2	-	-	-	-	-	-	-	-	-
Thinleaf alder	8	61	6	61	-	-	38	-	-	-	-	31	3	100	-
Red Twinberry	9	41	3	96	4	-	-	-	-	-	-	-	-	-	-
Trembling aspen	10	73	19	50	20	5	20	-	-	5	-	0	0	100	-
Black twinberry	11	38	8	88	5	5	-	-	-	-	-	-	-	-	-
Waxberry	11	3	<1	100	-	-	-	-	-	-	-	-	-	-	-
Currant	12	37	5	100	-	-	-	-	-	-	-	-	-	-	-
Douglas fir	13	17	5	67	-	-	25	-	-	8	-	-	-	-	-
Larch	14	0	0	-	-	-	15	-	-	85	-	-	-	-	-
Black cottonwood	15	69	25	44	44	-	-	-	-	11	-	14	3	100	-

* Only the most frequently browsed species are listed; a complete list is given in Appendix VI.
** Ranked according to percent occurrence.
+ Based on 220-9.3 m^2 plots.
++ Based on 115-9.3 m^2 plots.

ERICKSON PIT

The vegetation-types

Vegetation at Erickson Pit was classified into six communities (Figure 13): resloped and seeded, resloped and not seeded, wax-berry-aster (open brush), spirea-timothy (open grassland), mature forest and immature lodgepole pine forest (pine-spirea-pinegrass). These vegetation types can be described as follows:

1) resloped and seeded (clover-ryegrass): This was the resloped overburden planted in the spring of 1973 with trees, forbs and grasses (see Appendix III for species planted). Plant growth was lush and ground cover good (Figure 15). The predominant species was sweet clover, with some ryegrass and wheatgrass (Table 16). Generally alfalfa and grasses were not nearly as abundant as at McGillivray Pit primarily due to differences in aspect. A few areas on Erickson had a lush cover of grasses but as they were not representative of the reclaimed area, they were not chosen for vegetation transects.

2) disturbed and not seeded (daisy-timothy): This type was on flat or gently sloping ground and was naturally revegetating (Figure 14). Most exploration roads fall into this category. Predominant species were oxeye daisy, aster and timothy, with Canada bluegrass, slender wheatgrass and dandelion being common (Table 16).

3) waxberry-aster: This area was burned in the 1940's and many tall snags still stand, sometimes in dense groves (Figure 14). It is steeply sloping and very open, having no large trees. The ground cover was mostly forbs with very short shrubs and short trembling aspen trees. Predominant species were aster, waxberry, fowl bluegrass and oxeye daisy; other common species were pinegrass, rose, vetch, thistle, flat-top spirea, sedge and trembling aspen (Table 16).

4) spirea-timothy: This was an open shrub grassland area with scattered saskatoon and spirea shrubs, and some scattered conifers, mostly lodgepole pine, Douglas fir and larch (Figure 14). Predominant species were timothy, flat-top spirea, oxeye daisy, saskatoon and pinegrass.

5) mature forest: The tree layer consists of a fairly open stand of Douglas fir, lodgepole pine and larch, with some black cottonwood and white spruce. Shrubby undergrowth was about 1 m high (Figure 14). Predominant understory species included pinegrass, flat-top spirea, aster and strawberry. Other common species were soopolallie, oxeye daisy, and waxberry (Table 16).

6) immature lodgepole pine forest (Figure 14): This was essentially the same as the immature forest at McGillivray Pit. Only a few small patches of this forest occurred around Erickson Pit. A vegetation study was not done for this community because of its uncommoness and its similarity to the corresponding McGillivray type.

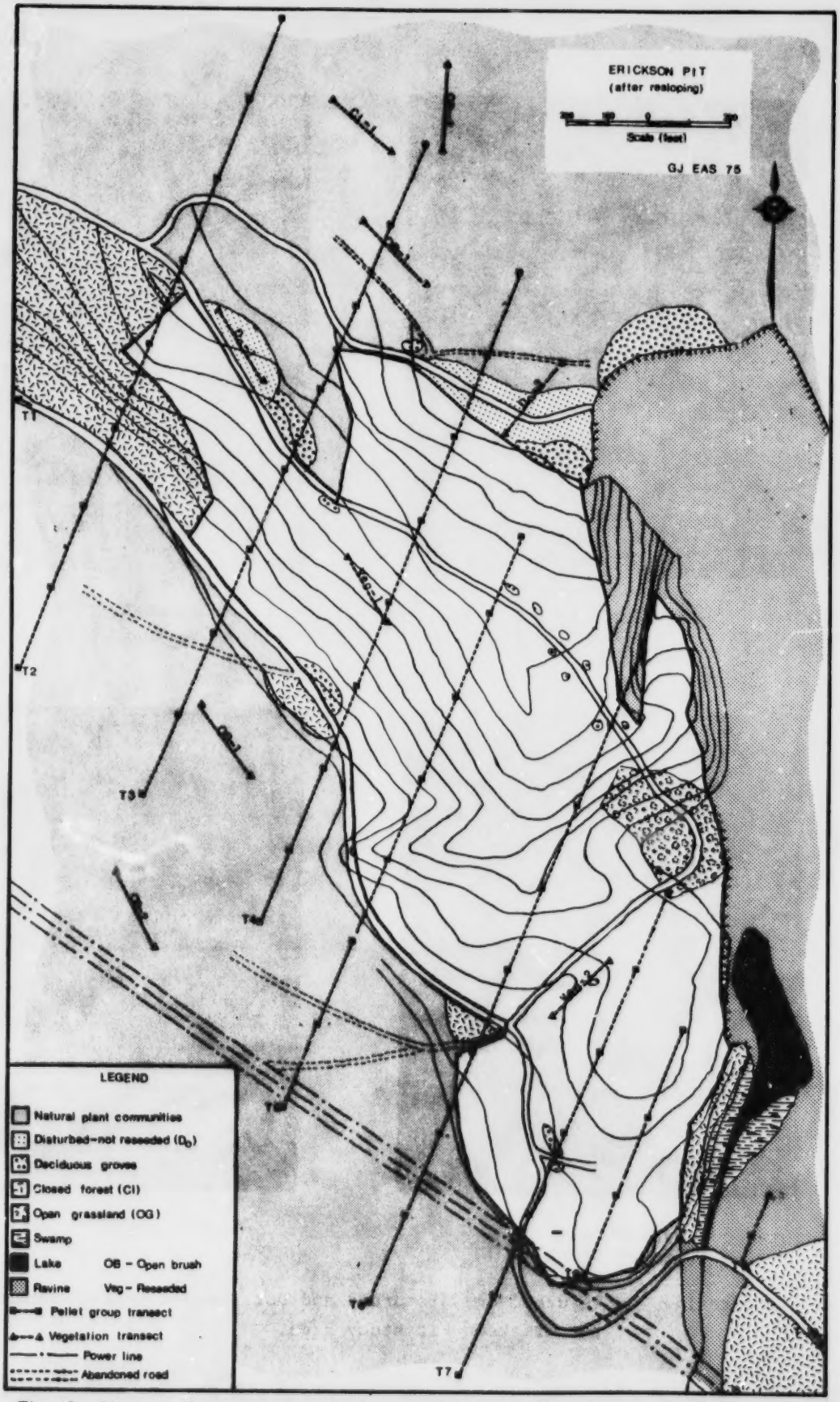
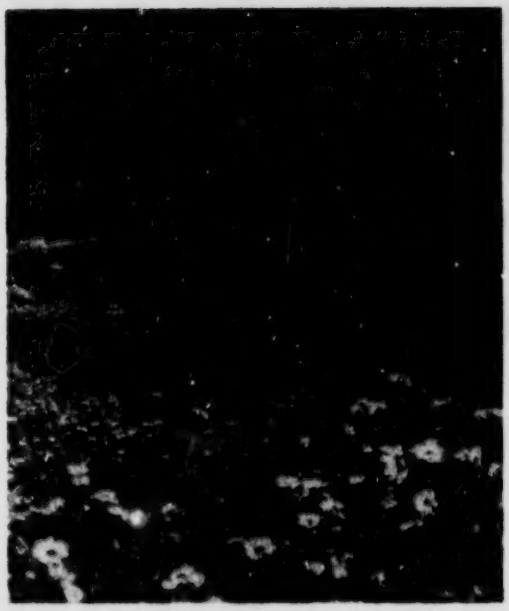
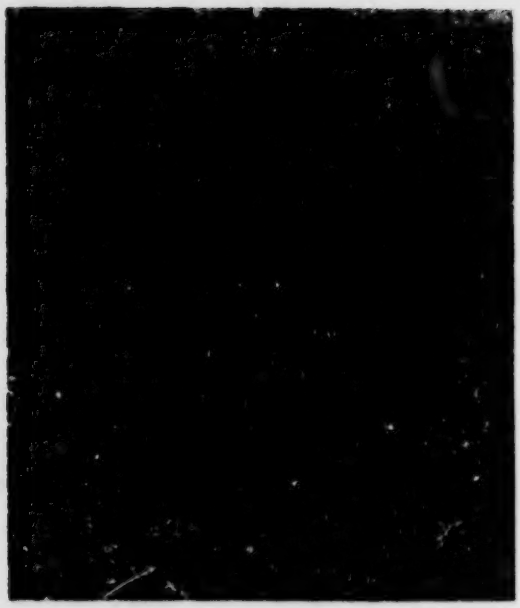


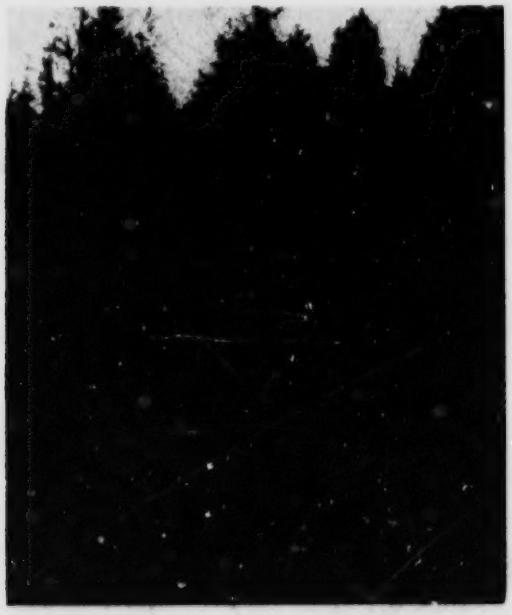
Fig. 13. Map of the transects, plant communities and contours of Erickson Pit.



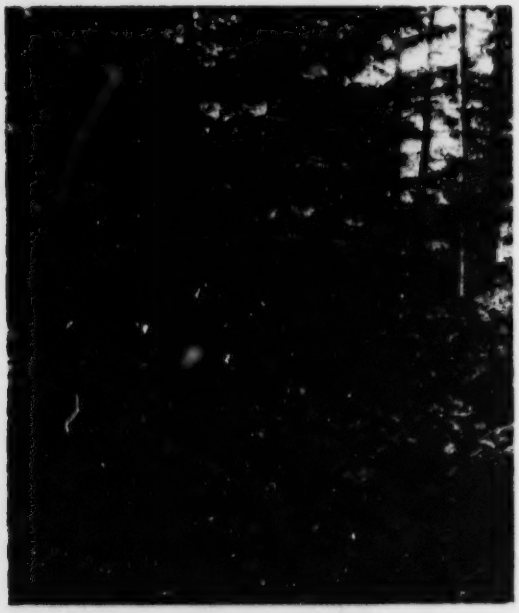
daisy-timothy
(disturbed and not
seeded)



waxberry-aster
(open grassland)



spirea-timothy
(open brush)



mature forest

Figure 14. Undisturbed and disturbed and not seeded plant communities at the Erickson Pit study area.

Table 16. Percent canopy coverage of major plant species recorded in the three undisturbed communities at Erickson Pit, August 1974.

Species*	Open grassland	Open brush	Mature forest
TREES AND SHRUBS			
Flat-top spirea	11	19	27
Rose	13	9	3
Saskatoon	-	16	1
Soopolallie	-	11	9
Trembling aspen	9	-	-
Waxberry	18	11	7
FORBS			
Aster	27	10	25
Hop clover	8	5	2
Oxeye daisy	16	16	8
Strawberry	<1	12	11
Thistle	12	1	-
Vetch	12	<1	<1
GRASSES AND SEDGES			
Canada bluegrass	-	8	-
Fowl bluegrass	17	-	1
Pinegrass	13	15	31
Sedge	10	4	3
Timothy	<1	29	3
No. of species with > 5% cover	14	15	14
Total no. species recorded	40	37	26
No. transects**	2	2	1

* Only species with greater than 5% cover are listed; complete lists of species in each community are given in Appendix V.

** 20 quadrats per transect.

Assessment of revegetation

Forage yields at Erickson Pit averaged about 160 g/m^2 annually between 1974 and 1976 (Table 17). This was intermediate to yields at the Placid Oil and McGillivray Pit study areas. However, unlike McGillivray Pit, the yields at Erickson Pit changed significantly each year. The yield for 1975 was significantly less than yields for 1974 and 1976. These changes were primarily due to variations in production of sweet clover, a biannual nurse crop, and alfalfa (cf. Table 18). Similar to McGillivray, yields were less variable than at Placid Oil with the average CV = 47% at Erickson, 50% at McGillivray, and 90% at Placid Oil.

Plant species diversity showed very little change during the 1974-76 period (Table 18). The total number of species recorded remained constant, the incidental presence of lamb's quarters in 1974 was the only difference (Appendix V). No native species were recorded in 1975 and 1976.

Cover of some plant species changed dramatically(Table 18, Figure 15). For example, over the three years, alfalfa increased from 1% to 34%,while sweet clover went from 77% to 15%. Coverage of the planted grasses was low, generally less than 10%. Crested wheatgrass and smooth brome showed upward trends in cover, while ryegrass declined.

Table 17. Forage yields of seeded vegetation at Erickson Pit, 1974-76.

Year sampled	Sample size	Yield (oven dry wt. g/m^2) (mean ± S.D.) total	grasses	forbs
1974	10	178±58	n.s.*	n.s.
1975	20	109±74**	79±63	30±51
1976	20	202±79**	64±51	138±98

* Samples not separated into grass and forb components.

** Yield significantly different from previous year.

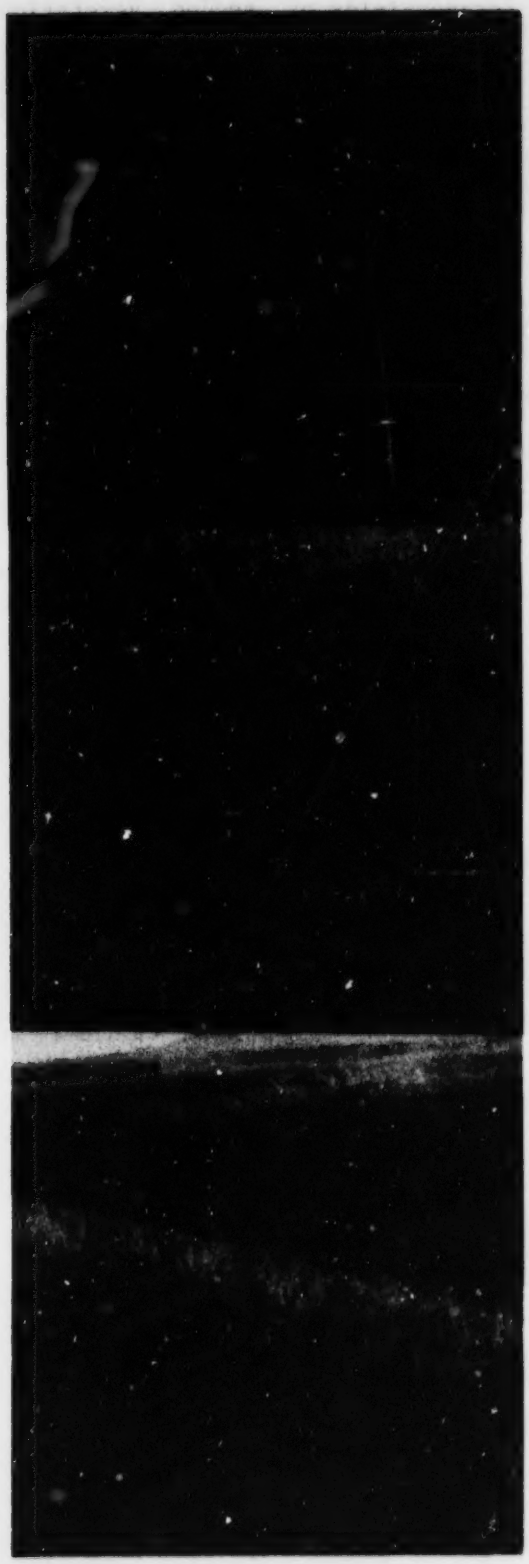
Table 18. Changes in percent canopy cover of plant species on the seeded area at Erickson Pit, 1974-76*.

Species**	Canopy-cover (%) 1974	1975	1976
FORBS			
Alfalfa	1	7	34
Sweet clover	77	3	15
GRASSES			
Crested wheatgrass	4	3	12
Intermediate wheatgrass	4	3	5
Ryegrass	14	10	<1
Smooth brome	<1	1	6
Total no. species recorded	10	9	9
No. transects+		2	

* Only species with greater than 5% cover are listed; complete lists are given in Appendix V.

** All species planted on the overburden.

\+ 20 quadrats per transect.



Photographed
July, 1974

Photographed
July, 1975

Photographed
August, 1976

Figure 15. Annual changes in seeded vegetation at Erickson Pit, 1974-76 (seeded in 1973).

Wildlife use

As with the other study areas, ungulate use varied both between plant communities and between years (Table 19). In the undisturbed types, use did not vary significantly between communities or years, although the forest was always used least. Annual changes in accumulated pellet group were not synchronous between types. The overall level of use was indicated by a mean of 1956 accumulated pellet groups/ha.

In the disturbed communities, use varied substantially in the seeded type (Table 19). In 1974, an average of 299 groups/ha were recorded. By 1976, this increased seven-fold to 2232 groups/ha. This change was most closely correlated with increased coverage of alfalfa. Other changes in species coverage and yields, or in use of the undisturbed communities were not correlated. We conclude that the increase in alfalfa was the main reason for the increase in use on the seeded vegetation type. In both 1976 and 1977, no significant differences occurred in use between the seeded and each of the undisturbed types except the closed forest in 1977 where the seeded type was significantly higher.

Table 19. Relative use of plant communities by wild ungulates at Erickson Pit, 1974-77, based on pellet group counts.

Plant community	Accumulated pellet groups per hectare 1974	1975	1976	1977	Means (4 yr.)
Disturbed					
Seeded	299(115)**	1568*(125)	2232*(96)	2211+(96)	1577
Not seeded	976(65)	1263(50)	1427(36)	1361(36)	1257
Disturbed means	638	1416	1830	1786	1417
Undisturbed					
Open brush	2367(25)	1840(35)	1753(28)	2222(28)	2045
Open grassland	2199(110)	2439(75)	2036(60)	2320(20)	2249
Closed forest	1485(90)	1568(55)	1906(44)	1340+(44)	1575
Undistrubed means	2017	1949	1898	1961	1956++

* There is a significant difference from the previous year's data.
++ There is a significant difference between the overall undisturbed mean and the overall disturbed mean.
** Number of 9.3m^2 plots in parentheses.
\+ There is a significant difference between use in the seeded type and the closed forest.

On the reclaimed sites, elk and deer appeared to use most of the seeded areas (Figure 16). They tended to congregate near a small plateau of seeded land overlooking the open grassland community. Elk were the most common ungulates found at Erickson Pit, though mule deer also used the area. Elk and deer in the natural communities appeared to prefer the open grassland which overlooks Michel Creek and Highway 3 and the open brush communities above the seeded area.

In the natural plant communities, the most frequently occurring shrub species were rose and soopolallie (Table 20). The former was browsed frequently but lightly and the latter rarely and very lightly. The most frequently browsed species were saskatoon, cottonwood, chokecherry, aspen and willow (Table 20). The most intensively browsed, however, was willow with a 63% estimate of leader shoot use. Aspen ranked next with an estimated 38% leader shoot use. Fifty-three percent of the willow plants were severely hedged whereas only three percent of the aspen were severely hedged. These figures indicate that the preferred browse species was willow followed by aspen. In the reclaimed area, rose was the most frequently browsed followed by cottonwood. Neither species was very intensively browsed (Table 20).

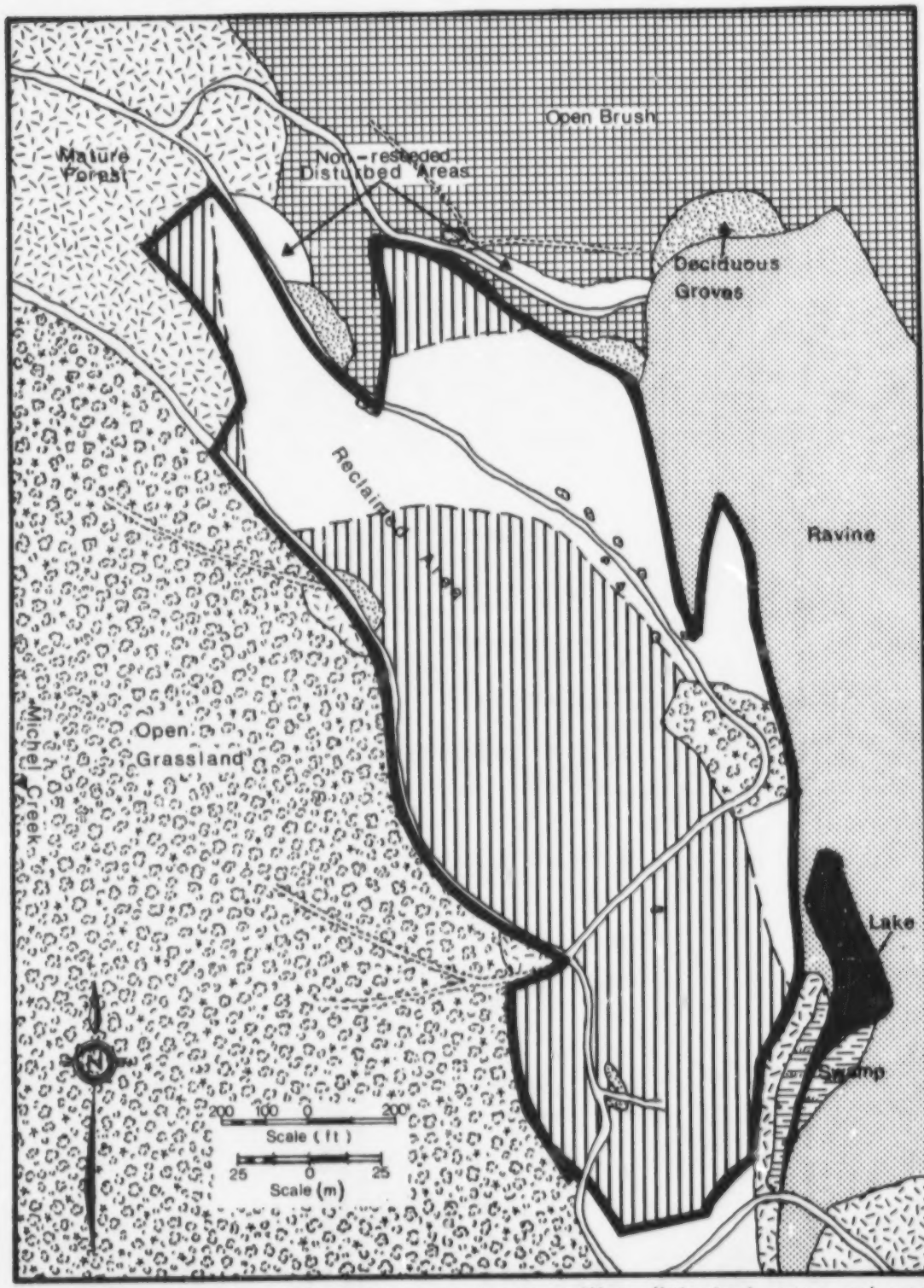


Fig. 16. Map of Erickson Pit showing plant communities, disturbed areas and areas of heaviest ungulate use on the reclaimed sites (▥).

Table 20. Frequency and intensity of browsing and condition of shrub species at Erickson Pit, 1975.*

Browse Species	Undisturbed communities +											Reseeded Areas++					
	Abundance (ranked)**	Frequency of browse within plot (%)	Average intensity of browse (%)	Form class (%)								Frequency of browse within plot (%)	Average intensity of browse (%)	Form class (%)			
				1	2	3	4	5	6	7	8			1	2	3	4
Rose	1	73	10	91	9	-	-	-	-	-	-	100	15	50	50	-	-
Soopolallie	2	27	5	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Waxberry	3	16	2	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Lodgepole pine	3	47	5	13	3	-	51	-	-	33	-	-	-	-	-	-	-
Trembling aspen	4	83	38	29	40	3	5	5	-	17	-	-	-	-	-	-	-
Willow	5	82	63	5	26	53	-	-	-	-	15	-	-	-	-	-	-
Flat-top spirea	6	13	3	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Saskatoon	7	100	23	53	42	-	-	3	-	-	-	-	-	-	-	-	-
Black cottonwood	8	94	21	48	24	4	16	4	-	4	-	63	13	50	25	-	25
Douglas fir	8	52	3	37	-	-	33	-	-	29	-	-	-	-	-	-	-
Chokecherry	9	92	25	46	53	-	-	-	-	-	-	-	-	-	-	-	-
Currant	9	46	2	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Thimbleberry	9	22	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-

* Only the most frequently browsed species are listed; a complete list is given in Appendix III.
** Ranked according to percent occurrence.
+ Based on 185-9.3 m^2 plots.
++ Based on 125-9.3 m^2 plots.

CONCLUSIONS

EVALUATION OF METHODS

Wildlife Use

The accumulated pellet group per hectare value in Tables 9, 14 and 19 is the total of all wild ungulate pellet groups encountered. This included both summer and winter groups as well as many old groups that could have been there since the areas were prepared for reseeding. In other words, the accumulated value could be an overestimate of the winter use on the reclaimed strip mines. To remedy this, we cleared the center plots at a station so that in future surveys, a more accurate pellet group count of wild ungulate winter use could be achieved. However, when we compared the results in 1976 and again in 1977 (McGillivray and Erickson Pits only) we found that there were no significant differences between the center plot only values and the other four plot values. The only exceptions were the shrub communities at Placid Oil Mine in 1976 and the open brush community of Erickson in 1977 where the center plot results were significantly lower than the other four plots. This difference might indicate that pellet groups in the shrub communities do not decay as quickly as in other areas and remain to be counted in consecutive years. Low (1959) found that in Utah, pellet groups under sagebrush usually persisted for about two years after which they were either covered by litter or washed away. In a five-year study Low also found that 93% of the original 58 pellet groups were still recognizable after three years. More research is needed, however, to substantiate our findings.

The method of recording browse used in 1975 took into account the frequency of occurrence of a species as well as the frequency and intensity of browse of that species. As a result, valid conclusions could be drawn on availability and use of browse as well as preferred browse species.

Hedging and leader use estimates were based only on the available forage. The three degrees of hedging gave a measure of plant vigour and forage production. In most cases, the current leaders on severely hedged plants were relatively short and less forage was available than on lightly or moderately hedged plants. Hedging assignments reflected the effects of leader use during the previous winter. Leader use estimates reflected on the intensity of use on browse plants. Allowable intensities of use will vary with the species of browse plants, the vigour of plants, the particular range site and the severity of the past winter.

Reclaimed area assessment

In 1975, we increased the sample size for the productivity clips because of the large standard deviations which occurred in the 1974 data. It did not work. The standard deviations remained high and appeared to be indicative of the patchy growth on the reclaimed sites.

The separation of grasses and forbs indicated the importance of each type to the particular reclaimed area and also showed the changes that occurred in 1975 and 1976, e.g., in 1975 grasses were more prevalent at McGillivray Pit but, in 1976, forbs became dominant. The ideal method, though, of estimating productivity would be to clip individual species in a plot and thus obtain a correlation between species and site.

The canopy-cover estimates gave a good indication of vegetation changes. Very few "new" species - ones that had not been previously recorded - occurred along the vegetation transects.

STUDY SITES

We found that wild ungulates were using seeded areas and, in some cases, to the same extent as the surrounding natural undisturbed areas. During the three year study period, there was an increase in use especially at McGillivray and Erickson Pits. Certain factors could account for this increase: fewer people working in the area, increased palatability of the vegetation on the seeded areas*, increased use of the open reclaimed areas as paths from one natural area to another, or a combination of all three.

In all three areas studied, certain features were the same. The animals tended to stay close to cover, to cross the reclaimed areas along specific paths or existing roads and to be attracted to water or runoff spots on the reclaimed areas. At Placid Oil, wild ungulates cross the disturbed areas at specific points. They foraged as they went, especially on the D-1974 areas. The vegetation "islands" became stopping places for cover as they crossed the disturbed area. Erickson Pit was more heavily used than McGillivray due to its more favourable exposure (SW) and also to its situation in a no-hunting zone.

* This factor could especially apply to McGillivray and Erickson Pits which are fertilized each year. Research has shown that fertilizer applications can increase plant nutrient levels (Duvall 1970).

RECOMMENDATIONS

Based on our observations and data collected, we offer the following recommendations. In our opinion, they are of value to further wildlife use of reclaimed areas.

(a) Before mining begins, a complete baseline study should be done including species composition and productivity clips. Reclamation should attempt to bring the land back to these or other suitably adapted species, and levels of productivity.

(b) During the mining of an area, "islands" of natural vegetation should be left wherever possible to provide not only a seed source but cover for wild ungulates. These "islands" should be planned for in the initial stages of the mining operation.

(c) More field trials should be carried out on the suitability of native forbs and grasses for the reclaimed areas. In choosing native forbs and grasses, emphasis should also be placed on palatability and nutritive value to wild ungulates.

(d) To enhance the reclaimed area for wild ungulates, more trees and shrubs, preferably browse species such as saskatoon and willow should be planted. For this, nurseries are required as well as descriptions for each species of site requirements such as soil, elevation, aspect, slope, precipitation and amount of sunlight.

(e) To supply a seed source and also to encourage wildlife use at the beginning of the reclaimation process, clumps of grasses, forbs and shrubs could be planted.

(f) Species suitability trials should be done to determine the best species for a particular area. Emphasis should be on eventually creating a diverse plant community of native species.

(g) The influence of various application rates of different fertilizers on annual growth, seed production, nutrient content and utilization should be defined on reclamation plant species. This study could then determine the most effective way to hasten the reclamation process through fertilization.

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APPENDIX I.

Common and scientific names of recorded plant and animal species.

MAMMALS (Source: Cowan and Guiguet 1965)

Elk	Cervus canadensis nelsonii
Moose	Alces alces
Mule deer	Odocoileus hemionus hemionus
Rocky Mountain bighorn sheep	Ovis canadensis canadensis
Whitetail deer	Odocoileus virginianus

TREES (Source: Hitchcock et al. 1969)

Birch	Betula sp.
Black cottonwood	Populus trichocarpa
Cherry	Prunus virginiana
Douglas fir	Pseudotsuga menziesii
Douglas maple	Acer glabrum var. douglasii
Dwarf juniper	Juniperus communis var. saxatilis
Engelmann spruce	Picea engelmannii
European white birch	Betula verrucosa
Larch	Larix occidentalis
Lodgepole pine	Pinus contorta
Manitoba maple	Acer sp.
Pin cherry	Prunus pensylvanicus
Ponderosa pine	Pinus ponderosa
Sitka alder	Alnus sinuata
Subalpine fir	Abies lasiocarpa
Thinleaf alder	Alnus tenuifolia
Trembling aspen	Populus tremuloides
White spruce	Picea glauca spp. glauca
Willow	Salix sp.

SHRUBS (Source: Hitchcock et al. 1969)

Bitterbrush	Purshia tridentata
Black twinberry	Lonicera involucrata
Blue clematis	Clematis columbiana
Creeping mahonia	Berberis repens
Currant	Ribes sp.
Dwarf huckleberry	Vaccinium caespitosum
Elderberry	Sambucus sp.
Flat-top spirea	Spiraea lucida
Grouseberry	Vaccinium scoparium
Kinnikinnick	Arctostaphylos uva-ursi
Mock orange	Philadelphus lewisii
Ocean spray	Holodiscus discolor
Red osier dogwood	Cornus stolonifera
Red raspberry	Rubus idaeus
Red twinberry	Lonicera utahensis
Redstem ceanothus	Ceanothus sanguineus

Rose	Rosa sp.
Saskatoon	Amelanchier alnifolia
Squashberry	Viburnum edule
Soopolallie	Shepherdia canadensis
Sticky laurel	Ceanothus velutinus
Thimbleberry	Rubus parviflorus
Twinflower	Linnaea borealis
Waxberry	Symphoricarpos albus

FORBS (Source: Hitchcock et al. 1969)

Alfalfa	Medicago sativa
Alsike clover	Trifolium hybridum
Alyssum	Alyssum alyssoides
Anemone	Anemone sp.
Arabis	Arabis drummondii
Arnica	Arnica cordifolia, A. latifolia
Aster	Aster sp.
Baneberry	Actaea rubra
Bedstraw	Galium asperrimum
Black medic	Medicago lupulina
Bluebell	Campanula rotundifolia
Blue-eyed Mary	Collinsia grandiflora
Bunchberry	Cornus canadensis
Buttercup	Ranunculus sp.
Campion	Silene menziesii
Chamomile	Matricaria discoidea
Cinquefoil	Potentilla gracilis
Clover	Trifolium sp.
Collomia	Collomia tinctoria
Columbine	Aquilegia formosa
Dandelion	Taraxacum officinale
Death camas	Zigadenus venenosus
Dogbane	Apocynum androsaemifolium
Dwarf goldenrod	Solidago spathulata
Evening primrose	Oenothera biennis
False forget-me-not	Lappula floribunda
False lady's slipper	Calypso bulbosa
False Solomon's seal	Smilacina racemosa
Filago	Filago arvens
Fireweed	Epilobium angustifolium
Fleabane	Erigeron sp.
Globe anemone	Anemone multifida
Golden aster	Chrysopsis hispida
Goldenrod	Solidago canadensis
Great mullein	Verbascum thapsus
Hop clover	Trifolim agrarium
Horse mint	Agastache occidentalis
Indian paintbrush	Castilleja sp.

Lamb's quarters	Chenopodium sp.
Lemonweed	Lithospermum ruderale
Lomatium	Lomatium sp.
Lupine	Lupinus sp.
Mariposa lily	Calochortus apiculatus
Nodding onion	Allium cernuum
Oval-leaf alumroot	Heuchera glabella
Oyster plant	Tragopogon dubius
Oxeye daisy	Chrysanthemum leucanthemum
Pea	Lathyrus sp.
Pearly everlasting	Anaphalis margaritacea
Penstemon	Penstemon sp.
Pink family	Caryophyllaceae
Pipsissewa	Chimaphila umbellata
Plantain	Plantago sp.
Purple fleabane	Erigeron speciousus
Pussytoes	Antennaria sp.
Pyrola	Pyrola sp.
Ragwort	Senecio canus
Red Clover	Trifolium pratense
Sarsaparilla	Aralia nudicaulis
Scouler's penstemon	Penstemon fruticosus var. scouleri
Self-heal	Prunella vulgaris
Smartweed	Polygonum aviculare, P. douglasii
Stonecrop	Sedum sp.
Strawberry	Fragaria sp.
Sweet clover	Melilotus alba, M. officinalis
Thistle	Cirsium sp., C. arvense , C. undulatum
Tumble mustard	Sysymbrium altissimum
Twisted stalk	Streptopus amplexifolius
Vetch	Vicia sp.
White clover	Trifolium repens
White fleabane	Erigeron caespitosus
White-leaved phacelia	Phacelia hastata var. leucophylla
Willow-herb	Epilobium sp.
Yarrow	Achillea millefolium
Yellow paintbrush	Castilleja sp.

GRASSES (Source: Hitchcock et al 1969)

Bearded wheatgrass	Agropyron caninum
Beardless wheatgrass	Agropyron spicatum
Bluegrass	Poa sp.
Blue wild-rye	Elymus glaucus
Canada bluegrass	Poa compressa
Creeping red fescue	Festuca rubra
Crested wheatgrass	Agropyron cristatum
Downy brome	Bromus tectorum
Fescue	Festuca sp.

Fowl bluegrass	*Poa palustris*
Intermediate wheatgrass	*Agropyron intermedium*
Junegrass	*Koeleria cristata*
Kentucky bluegrass	*Poa pratensis*
Meadow foxtail	*Hordeum jubatum*
Nugget bluegrass	*Poa* sp.
Oat	*Avena* sp.
Pinegrass	*Calamagrostis rubescens*
Poverty oatgrass	*Danthonia spicatum*
Richardson's needlegrass	*Stipa richardsonii*
Rough fescue	*Festuca scabrella*
Ryegrass	*Lolium* sp.
Sedge	*Carex* sp.
Sheep fescue	*Festuca ovina*
Slender wheatgrass	*Agropyron caninum*
Smooth brome	*Bromus inermis*
Tall fescue	*Festuca pratensis*
Tall wheatgrass	*Agropyron caninum*
Timothy	*Phleum pratense*
Western needlegrass	*Stipa occidentalis*
Williams's needlegrass	*Stipa williamsii*

APPENDIX II.

Animal observations, 1974 and 1975.

ANIMAL OBSERVATIONS - 1974

Species and date observed	Time	No. of animals seen	
		Disturbed area	Undisturbed area
Placid Oil			
1. Mule deer			
June 17	9:00 a.m.	-	1
June 19	10:00 a.m.	3	
	2:00 p.m.	-	1
June 22	4:00 p.m.	-	2
June 27	1:00 p.m.	-	1
July 10	9:15 a.m.	1	-
2. Elk			
June 6	11:00 a.m.	-	1
July 10	10:20 a.m.	-	35
McGillivray			
1. Elk			
May 15	10:00 a.m.	-	4
May 20	9:30 a.m.	-	2
July 25	10:00 a.m.	2	-
2. Mule deer			
July 10	2:15 p.m.	-	1
July 26	10:30 a.m.	-	1
3. Whitetail deer			
July 10	2:15 p.m.	-	2
4. Moose			
July 10	9:15 a.m.	2	-
Erickson			
1. Elk			
July 20	8:30 p.m.	1	-
2. Mule deer			
June 15	1:30 p.m.	-	3
July 1	10:00 a.m.	1	-
July 10	5:00 p.m.	1	-
July 30	10:00 a.m.	1	-
Aug. 8	10:30 a.m.	-	1
3. Black bear			
July 19	10:00 a.m.	2	-

ANIMAL OBSERVATIONS AT PLACID OIL MINE - MAY 1975

DATE	TIME	TEMP. (°C)	WEATHER	No. of animals seen					
				Disturbed area					Natural Area
				D-1972	D-1973	D-1974	D_L	D_O	
1. Mule deer									
May 2	7:15 a.m.	4	clear	-	5	2	16	-	-
May 4	2:00 p.m.	16	light overcast	-	-	6	7	-	-
May 5	8:45 a.m.	4	raining	-	-	3	-	-	-
	3:00 p.m.	12	heavy overcast	-	-	-	-	3	-
May 6	12:45 p.m.	10	light overcast	-	-	-	-	3	3
	2:00 p.m.	12	light overcast	-	12	3	-	5	-
	3:00 p.m.	14	light overcast	-	-	-	-	-	16
	5:00 p.m.	16	light overcast	-	-	-	-	1	-
May 7	9:15 a.m.	8	light overcast	-	-	-	1	5	14
	9:45 a.m.	8	light rain	-	-	8	-	-	-
	8:30 p.m.	12	clear	-	-	-	-	7	39
May 8	7:50 a.m.	5	clear	-	10	-	2	3	17
	8:30 a.m.	8	clear	-	8	-	2	-	-
	9:00 a.m.	9	clear	-	-	-	-	-	14
	3:00 p.m.	15	clear	-	-	-	-	5	6
May 9	7:30 a.m.	6	some cloud	-	-	-	-	-	12
	9:00 a.m.	9	some cloud	-	2	-	-	-	-
May 11	9:00 p.m.	12	clear	-	5	9	-	2	5
May 12	8:15 p.m.	17	clear	-	9	1	2	4	9
May 14	8:20 p.m.	20	clear	-	-	1	1	1	15
May 15	12:00 p.m.	18	overcast	-	1	-	-	-	-
May 16	10:00 a.m.	12	overcast	-	4	2	-	2	-
May 20	12:00 p.m.	14	broken cloud	-	3	-	-	-	-
May 21	7:35 a.m.	3	clear	-	-	-	-	-	5
May 24	7:50 a.m.	10	cloudy	-	-	-	-	-	4
2. Elk									
May 2	7:15 a.m.	4	clear	-	-	10	-		6
May 5	8:45 a.m.	4	raining	-	-	-	-		9
May 7	11:00 a.m.	6	light rain	-	-	-	-		7
May 8	7:50 a.m.	5	clear	-	-	-	4		2
May 9	7:00 a.m.	4	some cloud	-	-	3	5		-
May 12	8:15 p.m.	17	clear	-	-	-	-		3
3. Whitetail deer									
May 7	8:30 p.m.	12	clear	-	-	-	-		25
May 16	10:00 a.m.	12	overcast	-	-	2	-		-
4. Rocky Mountain bighorn sheep									
May 5	3:00 p.m.	12	heavy overcast	-	-	-	-		9

APPENDIX III.

Species planted at the three study sites.

Species	Minesites where planted		
	Placid Oil	McGillivray	Erickson
TREES AND SHRUBS			
black cottonwood		X	X
Douglas fir		X	X
European whitebirch		X	X
lodgepole pine		X	
trembling aspen		X	X
FORBS			
alfalfa		X	X
alsike clover	X		
sweet clover	X	X	X
GRASSES			
annual ryegrass		X	X
Canada bluegrass	X	X	X
creeping red fescue		X	X
crested wheatgrass	X	X	X
hard fescue	X		
intermediate wheatgrass		X	X
nugget bluegrass		X	X
perennial ryegrass		X	X
slender wheatgrass	X	X	X
smooth brome		X	X
tall fescue	X		
tall wheatgrass	X		
timothy	X	X	X

APPENDIX IV.

Canopy cover of plant species recorded on the undisturbed communities of the three study areas.

1. Placid Oil

Species	Percent canopy-cover			
	waxberry-dogbane	saskatoon -bluegrass	maple-waxberry	aspen-waxberry
TREES AND SHRUBS				
bitterbrush	7	6	-	-
birch	-	-	3	-
cherry	5	-	<1	13
creeping mahonia	8	<1	20	14
Douglas maple	<1	-	4	1
flat-top spirea	4	2	3	4
redstem ceanothus	8	-	-	-
rose	3	4	6	1
saskatoon	17	12	6	15
soopolallie	5	4	4	6
thimbleberry	<1	-	19	-
trembling aspen	-	<1	-	2
twinflower	-	-	<1	-
waxberry	24	6	25	39
willow	2	-	<1	<1
FORBS				
alyssum	<1	-	-	-
arabis	<1	-	-	-
arnica	<1	<1	10	1
aster	6	-	2	3
black medic	-	4	1	-
blue-eyed Mary	4	2	-	-
cinquefoil	1	-	-	-
collomia	2	-	-	-
dandelion	<1	-	1	-
death camas	1	<1	-	-
dogbane	19	<1	<1	6
false forget-me-not	-	<1	-	-
filago	<1	<1	-	-
great mullein	<1	-	-	-
horse mint	3	-	-	2
lemonweed	-	<1	-	-
lomatium	1	-	-	-
mariposa lily	-	-	-	<1
nodding onion	1	-	-	-
oyster plant	<1	<1	-	-

Species	Percent canopy-cover			
	waxberry-dogbane	saskatoon -bluegrass	maple-waxberry	aspen-waxberry
penstemon	<1	<1	-	-
pink family	-	4	-	-
pussytoes	<1	6	-	2
sarsaparilla	-	-	3	<1
self-heal	-	-	<1	-
stonecrop	<1	-	-	-
strawberry	2	-	2	1
twisted stalk	-	-	3	-
vetch	4	-	1	4
willow-herb	5	-	-	-
yarrow	6	6	-	-
GRASSES AND SEDGES				
bearded wheatgrass	<1	-	-	-
beardless wheatgrass	5	-	-	-
blue wild-rye	-	-	2	-
Canada bluegrass	7	25	<1	<1
downy brome	8	1	-	-
Junegrass	<1	4	-	-
Kentucky bluegrass	7	28	<1	-
pinegrass	4	-	8	32
poverty oatgrass	11	3	-	5
Richardson's needlegrass	-	6	-	-
rough fescue	-	2	-	-
sedge	2	1	-	-
slender wheatgrass	<1	-	-	-
timothy	8	2	-	-
unknown bunchgrass	-	-	2	-
western needlegrass	<1	-	-	-
William's needlegrass	-	-	1	-
OTHERS				
fern	-	-	2	-
lichen	-	28	-	-
moss	-	17	-	-

2. McGillivray

Species	Percent canopy-cover		
	open	immature forest	mature forest
TREES AND SHRUBS			
black twinberry	<1	-	3
blue clematis	3	-	-
creeping mahonia	<1	1	<1
currant	2	-	-
Douglas maple	2	-	-
dwarf huckleberry	-	8	-
flat-top spirea	19	18	23
grouseberry	-	9	<1
red twinberry	3	2	6
rose	3	2	<1
saskatoon	6	-	-
squashberry	-	-	2
soopolallie	-	9	23
thimbleberry	-	5	15
thinleaf alder	-	3	7
twinflower	-	14	3
white spruce	-	-	3
willow	-	-	4
FORBS			
arnica	<1	6	13
aster	<1	7	17
baneberry	-	-	<1
blue-eyed Mary	6	-	-
bunchberry	-	<1	2
campion	2	-	-
cinquefoil	1	-	-
columbine	-	-	7
dandelion	-	-	<1
dwarf goldenrod	2	-	-
false Solomon's seal	4	-	2
fireweed	-	<1	2
globe anemone	3	-	-
Indian paintbrush	2	-	-

Species	Percent canopy-cover		
	open	immature forest	mature forest
lupine	-	<1	<1
nodding onion	3	-	-
oval-leaf alumroot	6	-	-
penstemen	1	-	-
pipsissewa	-	<1	<1
pussytoes	5	-	-
pyrola	-	2	1
Scouler's penstemon	11	-	-
stonecrop	3	-	-
strawberry	5	-	3
twisted stalk	-	-	4
vetch	-	-	<1
willow-herb	-	-	<1
yarrow	3	-	-
GRASSES AND SEDGES			
blue wildrye	2	-	<1
Canada bluegrass	2	-	-
pinegrass	9	43	33
rough fescue	13	-	-
sedge	1	-	-
sheep fescue	2	-	-
timothy	<1	-	-
OTHERS			
ferns	<1	-	-
mushroom	-	<1	<1

3. Erickson Pit

Species	Percent canopy-cover		
	open grassland	open brush	mature forest
TREES AND SHRUBS			
black twinberry	-	<1	-
cherry	5	1	-
creeping mahonia	<1	5	5
currant	2	-	-
dwarf juniper	-	<1	-
flat-top spirea	11	19	27
lodgepole pine	<1	-	5
red raspberry	-	-	<1
rose	13	9	3
saskatoon	-	16	1
soopolallie	-	11	9
thimbleberry	<1	-	2
trembling aspen	9	-	-
twinflower	-	-	5
waxberry	18	11	7
willow	-	-	2
FORBS			
alsike clover	<1	-	-
anemone	-	<1	-
arnica	-	1	4
aster	27	8	25
bedstraw	-	<1	-
bluebell	-	<1	-
campion	3	-	<1
cinquefoil	1	<1	-
clover	-	-	2
dandelion	<1	-	-
death camas	-	<1	-
dogbane	2	-	-
false Solomon's seal	<1	-	-
fireweed	4	<1	-
fleabane	-	<1	-
goldenrod	4	<1	<1

Species	Percent canopy-cover		
	open grassland	open brush	mature forest
great mullein	1	<1	-
hop clover	8	5	-
lupine	3	-	<1
oval-leaf alumroot	-	<1	-
oyster plant	-	<1	-
oxeye daisy	16	16	8
pea	5	-	-
pearly everlasting	<1	-	-
penstemon	1	7	3
purple fleabane	1	-	-
pussytoes	<1	<1	<1
ragwort	-	<1	-
strawberry	<1	12	11
thistle	12	1	-
vetch	12	<1	<1
yarrow	4	2	-
yellow paintbrush	<1	-	-
GRASSES AND SEDGES			
Canada bluegrass	-	8	-
fowl bluegrass	17	-	<1
Junegrass	2	-	-
Kentucky bluegrass	<1	4	-
pinegrass	13	15	31
sedge	10	4	3
sheep fescue	1	-	-
slender wheatgrass	4	4	-
timothy	<1	29	3

APPENDIX V.

Percent canopy cover and frequency of occurrence of plant species recorded on the disturbed areas, 1974-76.

1. Placid Oil Mine

SPECIES	D - 1972				D - 1973						D - 1974						D_L					
	1974		1975		1974		1975		1976		1974		1975		1976		1974		1974		1976	
	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F
TREES AND SHRUBS																						
Black cottonwood	<1	3	8	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creeping mahonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	13	2	10	1	1
Flat-top spirea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	10	1	5	1	1
Rose	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	1	3	1	3
Saskatoon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7	4	13	7	11
Thimbleberry	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waxberry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	37	5	30	6	34
Willow	<1	5	3	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FORBS																						
Alsike clover	-	-	-	-	2	7	1	17	6	43	11	73	5	37	19	13	-	-	1	7	3	11
Alyssum	<1	3	-	-	-	-	-	-	-	-	<1	5	<1	5	-	-	<1	3	<1	3	<1	3
Aster	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	<1	8
Black medic	12	75	3	25	-	-	-	-	-	-	-	-	-	-	-	-	6	27	1	15	5	13
Blue-eyed Mary	2	25	<1	10	-	-	-	-	-	-	-	-	-	-	-	-	<1	47	<1	15	<1	12
Cinquefoil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	15	1	13	1	16
Dogbane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	55	15	43	15	58
Fleabane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	5	<1	3	<1	3
Great mullein	-	-	<1	5	1	3	-	-	-	-	1	7	<1	3	4	5	6	10	2	7	<1	13
Nodding onion	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	5	<1	3	-	-
Oyster plant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	15	1	17	3	24
Sow thistle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	28
Strawberry	1	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	5	<1	3	-	-
Sweet clover	2	10	7	5	4	17	-	-	-	-	-	-	19	57	-	-	-	-	3	10	2	13

1. Placid Oil Mine, continued

SPECIES	D - 1972				D - 1973						D - 1974						D_L					
	1974		1975		1974		1975		1976		1974		1975		1976		1974		1975		1976	
	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F	CC	F
Thistle	<1	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	27	4	27	<1	3
Vetch	<1	5	-	-	-	-	-	-	-	-	<1	3	-	-	-	-	<1	15	1	20	3	24
Violet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	8
Willow-herb	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-	-	2	17	1	23	<1	13
Yarrow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	43	6	45	7	58
GRASSES																						
Bearded wheatgrass	-	-	-	-	-	-	-	-	-	-	18	45	-	-	-	-	-	-	-	-	8	34
Beardless wheatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	25	-	-	-	-
Canada bluegrass	11	33	7	15	-	-	<1	3	<1	10	-	-	-	-	1	3	19	37	11	47	21	55
Crested wheatgrass	23	57	3	35	14	93	9	73	3	40	23	93	14	47	16	55	-	-	2	20	<1	8
Downy brome	2	3	<1	5	-	-	-	-	-	-	2	17	<1	3	<1	3	22	55	1	25	7	37
Intermediate wheatgrass	-	-	6	25	-	-	1	7	-	-	-	-	-	-	<1	3	-	-	4	13	-	-
Kentucky bluegrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	27	-	-	-	-
Pinegrass	-	-	<1	5	-	-	-	-	-	-	-	-	-	-	-	-	3	10	5	30	<1	16
Poverty oatgrass	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-
Sedge	-	-	<1	5	-	-	-	-	-	-	-	-	-	-	-	-	2	7	-	-	-	-
Slender wheatgrass	13	57	-	-	8	40	-	-	-	-	-	-	1	30	-	-	-	-	-	-	-	-
Smooth brome	-	-	-	-	-	-	-	-	-	-	-	-	1	13	1	18	-	-	-	-	-	-
Tall fescue	1	13	-	-	16	73	13	63	5	45	3	35	2	30	4	45	-	-	-	-	1	11
Tall wheatgrass	1	13	15	60	3	50	<1	3	-	-	2	35	7	40	<1	13	-	-	1	5	-	-
Timothy	16	60	15	30	17	90	12	55	4	35	7	60	3	45	13	85	7	30	3	35	10	66
Total No. Species Recorded	17		14		9		7		5		10		11		10		28		28		29	

2. McGillivray Pit

Species	1974		1975		1976	
	CC	F	CC	F	CC	F
TREES AND SHRUBS						
Black cottonwood	-	-	<1	3	-	-
FORBS						
Alfalfa	37	58	25	47	38	95
Red clover	<1	5	-	-	-	-
Sweet clover	45	50	3	15	13	43
Willow-herb	<1	15	-	-	-	-
GRASSES						
Canada bluegrass	1	47	9	47	9	50
Creeping red fescue	18	47	8	45	26	50
Crested wheatgrass	11	65	3	40	2	25
Intermediate wheatgrass	9	70	1	43	<1	10
Ryegrass	27	77	15	57	-	-
Slender wheatgrass	6	27	1	3	-	-
Smooth brome	5	30	<1	15	3	20
Tall wheatgrass	6	27	1	5	2	18
Timothy	16	45	9	50	8	45
Total no. species recorded	13		12		9	

3. Erickson Pit

Species	1974		1975		1976	
	CC	F	CC	F	CC	F
FORBS						
Alfalfa	1	10	7	33	34	90
Lamb's quarters	<1	3	-	-	-	-
Sweet clover	77	100	3	47	15	80
GRASSES						
Canada bluegrass	<1	3	1	20	4	38
Crested wheatgrass	4	33	3	63	12	70
Intermediate wheatgrass	4	33	3	35	5	38
Ryegrass	14	40	10	63	<1	3
Smooth brome	1	3	1	7	6	28
Tall wheatgrass	3	15	1	13	1	8
Timothy	<1	3	<1	13	<1	10
Total no species recorded	10		9		9	

APPENDIX VI.

Frequency and intensity of browse and form class data for shrub species at the three study areas.

FREQUENCY AND INTENSITY OF BROWSE AND FORM CLASS DATA OF BROWSE SPECIES IN PLANT COMMUNITIES OF PLACID OIL MINE, McGILLIVRAY PIT, AND ERICKSON PIT, 1975

1. PLACID OIL MINE - Natural Plant Communities

Browse Species	Frequency of occurrence (%)	Frequency of browse within plots (%)	Average intensity of browse (%)	Form Class (%)							
				1	2	3	4	5	6	7	8
Birch	3	31	8	-	7	-	38	-	-	53	-
Bitterbrush	8	97	9	76	18	-	5	-	-	-	-
Black cottonwood	1	33	23	33	-	33	-	-	-	33	-
Chokecherry	28	95	27	32	32	15	7	11	1	1	-
Creeping mahonia	6	3	<1	100	-	-	-	-	-	-	-
Douglas fir	3	25	7	13	6	-	-	-	-	75	-
Juniper	1	37	1	100	-	-	-	-	-	-	-
Kinnickinnick	<1	0	0	100	-	-	-	-	-	-	-
Lodge pole pine	1	75	36	-	25	-	-	50	-	25	-
Mock orange	1	75	3	25	-	-	50	25	-	-	-
Ocean spray	1	50	3	75	-	-	25	-	-	-	-
Pin cherry	4	89	23	52	21	5	5	15	-	-	-
Ponderosa pine	<1	50	45	-	-	50	-	-	-	50	-
Red osier dogwood	1	0	0	33	-	-	33	-	-	33	-
Redstem ceanothus	27	100	87	1	1	97	-	-	-	-	-
Rose	7	65	10	71	15	3	3	3	-	3	-
Saskatoon	67	99	44	8	32	20	7	27	3	<1	<1
Soopolallie	20	19	1	99	-	-	1	-	-	-	-
Spirea	2	30	5	90	10	-	-	-	-	-	-
Thimbleberry	1	75	25	50	25	-	-	25	-	-	-
Trembling aspen	13	47	15	14	11	1	23	9	-	41	-
Douglas maple	11	94	38	27	27	13	15	13	3		-
Waxberry	22	5	1	100	-	-	-	-	-	-	-
Willow	11	72	41	5	9	1	13	33	13	24	-

2. McGILLIVRAY PIT

A. Natural plant communities

Browse Species	Frequency of occurrence (%)	Frequency of browse within plots (%)	Average intensity of browse (%)	Form Class (%)							
				1	2	3	4	5	6	7	8
Black cottonwood	4	69	25	44	44	-	-	-	-	11	-
Black twinberry	7	38	8	88	5	5	-	-	-	-	-
Currant	4	37	5	100	-	-	-	-	-	-	-
Douglas fir	5	17	5	67	-	-	25	-	-	8	-
Dwarf huckleberry	2	-	-	100	-	-	-	-	-	-	-
Elderberry	<1	100	5	100	-	-	-	-	-	-	-
Engelmann spruce	20	23	1	11	-	-	81	-	-	7	-
Flat-top spirea	49	5	1	100	-	-	-	-	-	-	-
Juniper	1	0	0	100	-	-	-	-	-	-	-
Larch	5	0	0	-	-	-	15	-	-	85	-
Lodgepole pine	33	11	1	-	-	-	21	-	-	79	-
Red osier dogwood	1	100	16	75	25	-	-	-	-	-	-
Red twinberry	11	41	3	96	4	-	-	-	-	-	-
Rose	19	29	5	95	5	-	-	-	-	-	-
Saskatoon	19	93	20	61	37	2	-	-	-	-	-
Soopolallie	60	32	2	98	-	-	1	-	-	-	-
Squashberry	1	50	3	100	-	-	-	-	-	-	-
Subalpine fir	1	67	18	-	33	-	33	-	-	33	-
Thimbleberry	25	37	5	91	9	-	-	-	-	-	-
Thinleaf alder	15	61	6	61	-	-	38	-	-	-	-
Trembling aspen	9	73	19	50	20	5	20	-	-	5	-
Douglas maple	3	83	25	33	50	-	-	17	-	-	-
Waxberry	7	3	<1	100	-	-	-	-	-	-	-
Willow	35	91	63	13	10	53	1	3	13	-	-

2. McGILLIVRAY PIT

B. Reclaimed plant communities

Browse Species	Frequency of occurrence (%)	Frequency of browse within plots (%)	Average intensity of browse (%)	Form Class (%)							
				1	2	3	4	5	6	7	8
Black cottonwood	6	14	3	100	-	-	-	-	-	-	-
Flat-top spirea	1	0	0	100	-	-	-	-	-	-	-
Manitoba maple	-	-	-	-	-	-	-	-	-	-	-
Rose	-	-	-	-	-	-	-	-	-	-	-
Thimbleberry	3	67	17	67	33	-	-	-	-	-	-
Thinleaf alder	4	31	3	100	-	-	-	-	-	-	-
Trembling aspen	1	0	0	100	-	-	-	-	-	-	-
Soopolallie	1	0	0	100	-	-	-	-	-	-	-
Willow	3	100	43	25	75	-	-	-	-	-	-

3. ERICKSON PIT

A. Natural plant communities

Browse Species	Frequency of occurrence (%)	Frequency of browse within plots (%)	Average intensity of browse (%)	Form Class (%)							
				1	2	3	4	5	6	7	8
Black cottonwood	13	95	21	48	24	4	16	4	-	4	-
Chokecherry	7	92	25	46	53	-	-	-	-	-	-
Creeping mahonia	1	0	0	100	-	-	-	-	-	-	-
Currant	7	46	2	100	-	-	-	-	-	-	-
Douglas fir	13	52	3	37	-	-	33	-	-	29	-
Engelmann spruce	3	0	0	20	-	-	80	-	-	-	-
Flat-top spirea	16	13	3	100	-	-	-	-	-	-	-
Juniper	2	50	7	75	25	-	-	-	-	-	-
Larch	1	0	0	-	-	-	-	-	-	100	-
Lodgepole pine	21	47	5	13	3	-	51	-	-	33	-
Red raspberry	-	-	-	-	-	-	-	-	-	-	-
Red twinberry	3	80	4	100	-	-	-	-	-	-	-
Rose	43	73	10	91	9	-	-	-	-	-	-
Saskatoon	14	100	23	53	42	-	-	3	-	-	-
Soopolallie	29	27	5	100	-	-	-	-	-	-	-
Thimbleberry	7	22	1	100	-	-	-	-	-	-	-
Thinleaf alder	1	100	15	-	-	-	50	50	-	-	-
Trembling aspen	19	83	38	29	40	3	5	5	-	17	-
Twinflower	1	0	0	100	-	-	-	-	-	-	-
Waxberry	21	16	2	100	-	-	-	-	-	-	-
Willow	18	82	63	5	26	53	-	-	-	-	-

3. ERICKSON PIT

B. Disturbed and reseeded

Browse Species	Frequency of occurrence (%)	Frequency of browse within plots (%)	Average intensity of browse (%)	Form Class (%)							
				1	2	3	4	5	6	7	8
Black cottonwood	6	63	13	50	25	-	25	-	-	-	-
Rose	1	100	15	50	50	-	-	-	-	-	-